From State to Market: Essays on Electricity Sector Reforms

by

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Submitted for the degree of Doctor of Philosophy

Heriot-Watt University

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April 2013

Abstract

The 1980s marked the beginning of market driven reforms in the electricity sector based on the standard textbook model. More than half of the economies around the world have initiated power sector reforms since late 1980s irrespective of the sector size, resource endowments, institutional capacity and economic development. Hence, this thesis qualitatively and quantitatively assesses the process and outcomes of market-based reforms evolving the electricity sector across the developing, transition and developed economies where reforms are on-going at various stages. Deriving relevant and feasible reform options and policy for the electricity sector based on the lessons learnt after considering more than two decades of reforms remains the major contribution of this thesis.

Chapter one is the introductory chapter and provides an outline of the motivation and context of the thesis. Chapter two is a literature review of the experiences to date with the performance of electricity reforms across the reforming countries. The chapter identifies the knowledge gaps in the literature and sets the scene for the three substantial chapters of the thesis to follow.

The third chapter assesses the issues and options in reforming small electricity sectors considering the twin complicating factors of political instability and increasing electricity demand. The reform in the small electricity sector of Nepal is cited as a specific case. Chapter four empirically investigates the often poorly explored link between power sector reforms and wider institutional reforms in the economy across different groups of transition countries. The transition countries include the countries of Central and Eastern Europe and the Former Soviet Union. Chapter five examines the degree of market integration between the relatively small all-island Irish electricity market and other wholesale electricity markets in Europe. The chapter focuses on the role of interconnections and increased cross-border trade of electricity in the creation of an integrated market for electricity in Europe.

Chapter six concludes the thesis by highlighting the policy implications and areas for future research. The chapter establishes that electricity sector reform is prone to chronic political, market and regulatory failures in many reforming countries.

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Glossary

AB	Arellano-Bond
ADB	Asian Development Bank
ADF	Augmented Dickey-Fuller
AEPC	Alternative Energy Promotion Centre
AH	Anderson-Hsiao
AIM	All-Island Market
APX	Amsterdam Power Exchange
BB	Blundell-Bond
BELPEX	Belgian Power Exchange
BETTA	British Electricity Trading and Transmission Arrangements
Btu	British Thermal Unit
CBA	Cost-Benefit Analysis
CCGT	Combined Cycle Gas Turbine
CEB	Central Eastern Europe and Baltic States
CEGB	Central Electricity Generating Board
CER	Commissions for Energy Regulation
CGE	Computable General Equilibrium
CIE	Côte d'Ivorie Electricity Company
CIS	Commonwealth of Independent States
CNE	Comision Nacional de Energia
CPI	Consumer Price Index
CUSUM	Cumulative Sum
DEA	Data Envelopment Analysis
DECC	Department of Energy and Climate Change
DOED	Department of Electricity Development
DSM	Demand-Side Management
EBRD	European Bank for Reconstruction and Development
EC	European Commission
EDI	Energy Development Index
EEX	European Energy Exchange
EGRI	Economic Governance Reform Index
ELSPOT	Nord Pool Power Exchange
EMH	Efficient Market Hypothesis

ENRE	Ente Nacional Regulador de la Electricidad
ESB	Electricity Supply Board
ESI	Electricity Supply Industry
ETFC	Electricity and Tariff Fixation Commission
EU	European Union
EUAs	European Union Allowances
EXAA	Energy Exchange Austria
FE	Fixed Effect
FRI	Financial Sector Reform Index
FSU	Former Soviet Union
GB	Great Britain
GDP	Gross Domestic Product
GMM	Generalized Methods of Moments
GW	Gigawatt
GWh	Gigawatt Hour
HDI	Human Development Index
HDVC	High Voltage Direct Current
IADB	Inter-American Development Bank
IEA	International Energy Agency
IMF	International Monetary Fund
IPPs	Independent Power Producers
IPPAN	Independent Power Producer' Association of Nepal
IV	Instrumental Variable
KM	Kilometre
KPSS	Kwiatkowski; Phillips; Schmidt and Shin
KV	Kilovolt
KW	Kilowatt
KWh	Kilowatt Hour
LACs	Latin American Countries
LOOP	Law of One Price
LSDV	Least Square Dummy
MLE	Maximum Likelihood Estimator
MOCS	Ministry of Commerce and Supplies
MOE	Ministry of Energy
MOEN	Ministry of Environment

MW	Megawatt
NAIRU	Northern Ireland Authority for Utility Regulation
NEA	Nepal Electricity Authority
NIE	New Institutional Economics
NOC	Nepal Oil Corporation
nTPA	Negotiated Third-Party Access
NRs	Nepalese Rupees
OECD	Organisation for Economic Co-operation and Development
OIRI	Other Infrastructure Reform Index
OLS	Ordinary Least Squares
OMLI	Overall Market Liberalisation Index
OTC	Over-the-Counter
PEPDN	Per Capita Electricity Production
PGDP	Per Capita Gross Domestic Product
PINSTC	Per Capita Installed Capacity
PPA	Power Purchase Agreements
PRI	Power sector Reform Index
PRINSTC	Per Capita Renewable Installed Capacity
PTDL	Per Capita Transmission and Distribution Losses
RE	Random Effect
REB	Rural Electrification Board
REP	Rural Energy Policy
RMSE	Root Mean Square
rTPA	Regulated Third-Party Access
SAARC	South-Asian Association for Regional Cooperation
SBM	Single-Buyer Model
SCBA	Social Cost Benefit Analysis
SEE	South Eastern Europe
SEM	Single Electricity Market
SEMO	Single Electricity Market Operator
SFA	Stochastic Frontier Analysis
SIC	Schwarz Information Criterion
SMP	System Marginal Price
SRMC	Short Run Marginal Cost
T&D	Transmission and Distribution

TECs	Transition Economies
TFP	Total Factor Productivity
TSO	Transmission System Operator
TWh	Terawatt Hour
UK	United Kingdom
UKPX	United Kingdom Power Exchange
UNDP	United Nations Development Programme
UREGNI	Utility Regulator of Northern Ireland
USA	United States of America
USD	United States Dollars
USAID	United States Agency for International Development
WECS	Water and Energy Commission Secretariat

List of Publications

1) Nepal, R. and Jamasb, T. (2012). Interconnections and Market Integration in the Irish Single Electricity Market, *Energy Policy,* Vol. 51, December, pp. 425-434.

2) Nepal, R. and Jamasb, T. (2012). Reforming the Power Sector in Transition: Do Institutions Matter?, *Energy Economics,* Vol. 34 (5), pp. 1675-1682.

3) Nepal, R. (2012). Roles and Potentials of Renewable Energy in Less-Developed-Economies: The Case of Nepal, *Renewable and Sustainable Energy Reviews*, Vol. 16 (4), pp. 2200-2206.

4) Nepal, R. and Jamasb, T. (2012). Reforming Small Electricity Systems under Political Instability: The Case of Nepal, *Energy Policy*, Vol. 40, January, pp. 242-251.

5) Growitsch, C. and Nepal, R. (2011). Electricity Spot Trading in Germany: Price Formation and Convergence, *Energy Studies Review*, Vol. 18 (1), pp. 35-46.

6) Jamasb, T. and Nepal, R. (2010). Issues and Options in Waste Management: A Social Cost-Benefit Analysis of Waste-to-Energy in the UK, *Resources, Conservation and Recycling*, Vol. 54 (12), pp. 1341-1352.

7) Jamasb, T., Nepal, R., and Kiamil, H. (2010). Waste to Energy in the UK: Policy and Institutional Issues and Options, *Proceedings of the Institution of Civil Engineers, Energy*, Vol. 163(2), pp. 79-86.

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Chapter 1: Introduction

The aim of this thesis is to explore the experiences to date with the process and outcomes of market-oriented reforms in the electricity sector across the developing, transition and developed economies. The major contribution of the current work remains in deriving relevant reform options and policy recommendations for the electricity sector based on the lessons learnt after more than two decades of reforms in the global electricity industries.

1.1. The Standard Textbook Model for Reforms

Market driven electricity sector reforms have been initiated in more than half of the economies around the world since the early 1980s. The importance of the electricity industry in domestic production and economic development implied that reforms in the sector were crucial. The power sector is the growth engine of modern industrial and developing economies. The centralised and natural monopolistic characteristics of the power systems often conceptually make them a public utility. Hence, the results from reforms in the power sector matter and can serve as important economic and political tests for any government undertaking power sector reforms.

The early 1980s gave birth to the 'standard textbook model' for organising and restructuring the electricity sector across countries. The model was based on market-oriented liberal policies and typically constituted of three fundamental components (Joskow, 2008). The first element involved the vertical separation or unbundling of the potentially competitive segments (generation, marketing and retail supply) from the natural monopoly segments (the transmission and distribution networks). The model assumed that not all aspects of the electricity supply industry are monopolistic and electricity can also be generated and supplied by private and competitive firms apart from the state. Preventing cross-subsidization of competitive businesses from regulated businesses and promoting competition by guarding against any discriminatory network access policies were the principal drivers behind separating the competitive segments of the electricity supply industry (ESI) from the monopoly segments.

The second component of the model underscored the need and role of private ownership of the competitive segments of the ESI on the notion that private entities could better allocate the scarce capital resources and ensure efficient management of the system. It was perceived that privatisation of state-owned electricity monopolies will create hard budget constraints and high-powered incentives for efficiency improvements and make it more difficult for the state to use these industries in order to meet costly political agendas such as patronage employment, unfavourable macroeconomic and redistributive policies and national revenue diversion to government budgets outside of the tax system (Joskow, 2006).

The third component of the standard model stressed the need to create powerful and effective new institutions in the form of independent regulators and regulatory agencies. An independent regulator would act as the custodian of public interests (Armstrong et al., 1994). It was expected that an independent regulatory authority with adequate staff, powers, duties and information about the costs, service quality and performance of the ESI will ensure proper conduct in the industry by effectively implementing the incentive regulation of the monopoly segments in terms of market entry, network charges and network access. Hence, it was assumed that incentive regulation of monopoly electricity networks will mimic the outcomes of a competitive market (Littlechild, 1992).

Other components of the textbook model included the horizontal restructuring of the generation segment to create adequate number of competing generators and suppliers, designation of an independent system operator to maintain network stability and facilitate competition, creation of voluntary public wholesale spot energy and ancillary services markets and trading arrangements, application of regulatory rules to promote access to the transmission networks, unbundling of retail tariffs and rules to enable access to distribution networks and provision of transition mechanisms that can anticipate and respond to problems and facilitate the transition process (Joskow, 2000; Hunt, 2002).

1.2. Factors Driving the Reforms

Chile became the first developing country in the world to apply the 'standard textbook model' in 1982 and was soon followed by UK (1989) and Norway (1990). The Chilean reform sequence involved the following steps: i) establishment of the electricity market regulator at the start, ii) corporatization of state-owned enterprise, iii) law for electricity sector liberalisation, iv) unbundling (or vertical separation) of the main segments, v) incentive regulation of electricity networks, vii) establishment of a wholesale electricity market, viii) introduction of privatisation and ix) introduction of private independent power producers (IPPs).

The success of the model in Chile, UK and Norway demonstrated the great potential of introducing market-based reforms and incentive regulation in other countries around the world signalling the advent of modern electricity reforms. The remarkable pace and extent of the reforms meant that many advanced economies and around 70 developing and transition countries had adopted some market driven reform steps in their electricity sectors by the end of 1990s (Bacon, 1999; Steiner, 2001). The reform measures implemented across these countries varied from partial to complete adoption of the 'standard textbook model'. For example, a developing country like Nepal has only pursued minimal structural changes in the electricity sector although IPPs have been introduced while a developed economy like Ireland has already reached the advanced stage of the standard reform model with the creation of an organised wholesale spot market for electricity.

However, the demonstration effect from early success stories was just one of the major drivers of electricity sector reforms around the world. A combination of political, economic and technological factors enabled a remarkable world-wide experiment of introducing market-based reforms and restructuring of the electricity sector starting the early 1980s across the developed, transition and developing economies.

1.2.1. Developed economies

The advanced economies such as those belonging to the Organisation for Economic Co-operation and Development (OECD) experienced a lack of electricity demand growth after the oil crisis of the 1970s. The adverse incentives of over-capitalisation under rate-of-return regulation were also criticized (Averch and Johnson, 1962). Hence, the electricity industry in the developed countries were characterised by excess capacity coupled with the use of expensive generation technologies and productive inefficiency (Jamasb et al., 2005). Improving financial and economic performance of the ESI remained the major aim of pursuing reforms in developed economies. Ideological reasons also provided reasoning for reforms in these economies as exhibited by the privatisation of the state-owned electricity utilities in the United Kingdom (UK) which reinforced the ideology of the Thatcher government. The development of gas-fired combined cycle gas turbines (CCGTs) and improvements in information and communication technology reduced the significance of economies of scale and facilitated the separation between generation and transmission segments of the ESI.

In advanced economies such as the European Union (EU), the motive for reforms also came as an initiative from the European Commission through two electricity directives during 1996 and 2003 in the pursuit of a common integrated market for electricity (Newbery, 2002a). The EU directive 96/92/EC laid down the foundations concerning common rules towards creating an internal market for electricity. The 2003 directive established several key objectives to be achieved by 1 July, 2007 such as creating an independent regulator, 100% market opening to all customers including households, legal unbundling of the network segments from generation and supply and free entry in generation via a non-discriminatory network access to third-parties. In addition, the EU Directive 2009/72/EC underscored the need to mitigate barriers to cross-border trade and expand interconnections for creating an integrated market for electricity in Europe.

However, the European reform model excludes some aspects of the standard model that are present in some of the leading reforming nations such as the UK. It is not mandatory to completely privatise the state-owned assets although there is a requirement to increase private sector participation in the market as demonstrated by successful electricity liberalisation in Norway and Sweden. The ownership unbundling of transmission system operation or transmission assets is also not required in the EU directives though independent system operation exists in many of pioneer reforming countries. Nonetheless, the integration of small economies and island states such as Ireland in the wider EU market currently remains an interesting political and economic challenge for Europe in the creation of an integrated and common electricity market. The challenge of establishing an integrated market for electricity becomes bigger when market integration goals have to be pursued along with the climate change and security of supply targets.

1.2.2. Developing and transition economies

In developing and transition countries, reforms were particularly driven by the operational and economic inefficiency of the state-led vertically integrated utilities, the inability of the state sector to raise adequate capital, the lack of electricity access across the population, deteriorating facilities and equipment, serious problem of theft and non-payment, the need to remove state subsidies for better allocation of resources and the desire to raise immediate revenue for the state through sale of state assets (Joskow, 1998; Bacon and Besant-Jones, 2001; Kessides, 2004). The macroeconomic crisis of the 1980s also created a regime of fiscal responsibility in developing and transition countries. High inflation levels, increasing debt burden and deterioration of the quality of public services garnered political support towards liberalisation of the electricity industries.

The shift from a vertically integrated public monopoly to a more competitive power sector by undertaking the structural, regulatory and ownership reforms was also strongly encouraged by the World Bank, International Monetary Fund (IMF) and other international financial institutions in developing and transition countries. The World Bank officially changed its lending policy in 1992 for power sector development from traditional project lending to policy lending implying that any borrowing country should adopt the market-based standard reform model. This background explains the appeal of privatisation and market-oriented reform in developing and transition economies which, at times, preceded other necessary reform measures (Jamasb, 2006).

The allure of utility privatisation was particularly strong among the transition countries (the countries of the Central and Eastern Europe and the former Soviet Union) and the Latin American countries (LACs). The transition countries experienced massive market-oriented systemic changes in all sectors of their economy from the early 1990s. The structural change included aspects like macro stabilisation, price liberalisation, eliminating institutions of the communist systems and openness to international trade. These reforms were termed as Type I reforms while Type II reforms included the design and enforcement of laws, regulation and proper institutions to support and nurture the functioning of the market driven reforms (Svejnar, 2002). Large-scale economic privatisation combined with the establishment of legal institutions in establishing well-defined property rights and contracts and anti-corruption agencies were the major hallmarks of the Type II reforms.

In the Latin American context, the first electricity privatisation took place in Chile in 1982, followed by Argentina in 1992 and some privatisations in Brazil. The appeal of utility privatisation grew following these early experiences in other LACs such as Peru, Colombia and Bolivia. Privatisation coupled with wholesale market competition and independent regulation were the major elements of reform among the developing countries of Latin America.

1.3. Context of Reforms

The initial context of reforms varied across the reforming countries that underwent the wave of market-based electricity reforms. Resource characteristic and sector endowment, initial sector structure and institutional strength evolving the electricity sector differed across the reforming countries at the start of the reform process.

1.3.1. Size of the sector

The size of the electricity sector is a crucial but often ignored concept in electricity sector reforms. The size of the electricity system can generate substantial influence on the reform capabilities and reform options of individual reforming countries. Hence, not all reform elements prescribed by the standard textbook model are appropriate across all reforming countries. For example, it is not clear if small electricity systems also require or benefit from vertical separation and third-party access. The scope for competition may be limited. This suggests that the benefits of adopting a full reform package may be small in relation to the costs in small electricity systems. However, the importance of sector size on the determinants and performance of reforms has not received adequate attention in electricity reform literature implying a considerable knowledge gap. Bacon (1999) provided important information on the extent of reforms possible in small electricity systems which clearly motivates studying the impacts of different stages of reform on performance among reforming countries with varying sector endowments.

1.3.2. Sector structure

The initial sector structure at the time of reform is a function of the sector's history, resource endowment and past policies. The initial structure defines the starting point of the reform process and is a given factor (Jamasb et al., 2004). For example, the transition countries inherited the features of the command economy in the power sector which led to politically determined power prices, excess capacity and high levels of electrification at the start of economic liberalisation.

However, the reform measures adopted have a direct impact on the performance of the sector. Reforms take time to implement and produce the desired effects. Hence, it is important that the appropriate structure is envisaged from the start of the reform process (Jamasb et al., 2005). For example, the transition countries adopted market-oriented reforms in the electricity sector but did not effectively create suitable institutions to support the market driven reforms. Whether the reform in the electricity sector worked or not is a matter of empirical investigation and is clearly missing in the past literature studying electricity sector reforms.

1.3.3. Institutional factors

Institutional factors refer to the sector and economy level legal and regulatory frameworks that influence and support the continuity of the electricity sector reform process. According to North (1991), institutions are humanly devised constraints that structure human interaction at the political, economic and social levels, provide an incentive structure of an economy, create order and reduce uncertainty in exchange. From an institutional economics perspective, institutions constitute two essential components: the institutional environment and institutional arrangement (Williamson, 1995). The institutional environment is concerned with macro-level 'rules of the game' which can be formal or informal while institutional arrangements focus on micro-level governance mechanisms. The institutional endowment of a country influences the institutional environment and includes five elements: legislative and executive system, judicial system, administrative system, informal rules and social and ideological character of the nation (Levy and Spiller, 1994).

The reforms and regulation of the electricity sector in developing countries tend to suffer from low levels of institutional environment in terms of limited regulatory capacity, limited accountability, limited commitment and limited fiscal efficiency (Laffont, 2005). The weak institutional environment implies that reforms and regulation of the electricity sector can be ineffective. Regulation becomes prone to political capture becoming a tool of self-interest within the government or ruling elite (Stiglitz, 1998). In contrast, developed countries have robust institutional frameworks and arrangements in place as they have a high institutional endowment. Hence, implementing reforms and regulation of the sector is easy and feasible in developed economies. Whether reforms and regulation of the electricity sector in developed economies is effective or not requires exact empirical testing. This is because many developed countries have already exhausted the reform steps under the standard model implying that current reforms are driven by the need to meet different national and regional objectives. For example, an isolated small island developed economy like Ireland with robust institutions in place faces major challenges to increase market integration with other wholesale electricity markets in Europe by expanding interconnections.

1.4. Structure of the Thesis

Reforms are on-going in many countries while the reform process in the electricity sector is regarded as not only possible, but also inevitable. Ample amounts of financial resource and effort have already been spent in reforming the electricity sector across all developing, transition and developed economies since the 1980s. What reform lessons can be learnt, in general, from these electricity reform experiences for an economy that is willing to undertake reforms? In particular, what lessons can be learnt from the theoretical and empirical analysis of electricity reform experiences across countries where electricity reforms were separately initiated due to pressures from external lending policy, as a consequence of overall transition towards market-driven economic reforms and as a consequence of successful reform experience in the UK with the need to comply to the EU directives? These are the questions this thesis aims to answer.

Chapter 2 of the thesis provides a literature review on the theoretical and empirical evidence of reform performance in developing, transition and developed economies.

The literature review also identifies the caveats in existing literature on electricity sector reforms.

Chapter 3 of the thesis assesses the issues and options in reforming small electricity systems citing Nepal as a specific case. Nepal is a developing country in South Asia where reforms seem to have stalled after undertaking minimal structural changes and introducing IPPs. The Nepalese electricity sector also initiated reforms in the electricity sector since the early 1990s, often due to direct lending pressures from international financial institutions. However, increasing electricity demand and political instability remain the complicating factors obstructing the implementation of reforms in the state-owned electricity sector among less-developed countries like Nepal which this chapter attempts to account for.

Chapter 4 of the thesis quantitatively examines the impact of market-oriented reforms in the economy including the power sector and their effect on the power sector outcomes and economic growth in the transition countries using panel-data econometrics. The transition countries represent a remarkable electricity reform experiment in the world as many of these countries have a clear reform model to follow from the EU with access to substantial amount of resources or technical assistance and reform is on-going in the context of associated macroeconomic and governance reforms (Pollitt, 2009). The emergence of transition economies also coincided with the world-wide trend in power sector reforms. Hence, market-oriented electricity reforms started after the collapse of communism in the context of overall macroeconomic transformation in transition countries. Furthermore, the transition countries are of special interest in the context of analysing electricity sector reform because they include a diverse mix of countries belonging to different stages of economic development and different stages of the reform process.

Chapter 5 of the thesis quantitatively studies the restructuring and reform of a small and isolated Irish wholesale electricity market located in an island economy. The Single Electricity Market (SEM) is a relatively new wholesale market in Europe and started its operation in November of 2007 in line with the EU policy guidance. However, lack of sustained competition and market power concerns imply that expanding interconnections can be a feasible solution to improve competition and market integration in SEM as per the EU policy of creating an integrated market of electricity in Europe. This chapter estimates the degree of market integration between SEM against other large, mature and well-established electricity wholesale markets in Europe including Great Britain (GB) using advanced time-series econometrics.

Chapter 6 concludes the thesis by outlining the findings from the three empirical chapters, and attempts to combine the results and interpret them in the context of global electricity reforms. This chapter also highlights the contributions of the research and suggestions for future work.

Chapter 2. Review of the Literature

Economic principle suggests that a reform should be undertaken if the reform adopted will engender a net positive economic welfare impact. This implies that a social-cost benefit analysis (SCBA) prior to reform is a pre-requisite to assess the effectiveness of reforms. A SCBA considers reforms and restructuring as an investment and compares the costs of investment with the benefit which is the change in actual and projected performance relative to a defined counterfactual of what would have happened in the absence of reform and restructuring (Jones et al., 1990). Hence, a SCBA estimates the overall welfare impact of reforms and distribution of welfare among government, consumers and private investors. However, governments do not necessarily perform social-cost benefit analysis prior to reform and tend to rely on less formal types of assessment (Jamasb et al., 2004). A limited number of notable studies assess the efficacy of electricity reforms and restructuring using SCBA, mostly in the Latin American and European context.

Galal et al. (1994) estimated that the privatisation of the Chilean distribution and generation companies led to a permanent gain in social welfare equivalent to 2.1% of 1986 sales although two-thirds of the aggregate gains go to foreign shareholders. Mota (2003) found out that the privatisation of distribution companies in Brazil created a one-off gain equal to 2.5% of national Gross Domestic Product (GDP) while producers gain around two-thirds of the benefits. Anaya (2010) calculated the welfare impacts of privatisation of two retailing and distribution companies in Peru. The study estimated a permanent gain of 27% of costs. Toba (2002) concluded that the privatisation of Meralco, a distribution company in Philippines, contributed to a permanent gain equalling 6.5% of 1999 sales. Another study by Toba (2007) estimated that the introduction of independent power producers by incumbent generator created a one off gain amounting to 13% of national GDP of Philippines.

In the UK context, Newbery and Pollitt (1997) estimated that the privatisation and separation of the Central Electricity Generating Board (CEGB) into generation and transmission led to a permanent gain in welfare equivalent to 6% of 1995 turnover even though consumers lose initially. Pollitt (1999) applied a social cost-benefit analysis methodology, similar to that by Newbery and Pollitt (1997), to the Scottish electricity systems. The study estimated that efficiency gains from privatisation in the Scottish system, under the more probable counterfactual scenario, were relatively small at about 10% of turnover as compared to 50% in England and Wales. Green and McDaniel (1998) applied SCBA to examine the economic merits of full market opening in the ESI of England and Wales. The results showed that full market opening result in lower prices but with additional transactions costs exceeding £100 million a year for the first five years. Domah and Pollitt (2001) found out that the privatisation of 12 regional electricity distribution companies in the UK lead to a permanent gain equivalent to 9% of 1995 turnover. The study showed that consumers begin to gain only from 2000 while the government gains £5 billion in sale proceeds and net taxes. The latter study by Domah and Pollitt (2001) confirms the finding of the previous study by Newbery and Pollitt (1997) in asserting that consumers lose initially in the privatisation process. Barmack et al. (2007) estimated the net benefits of wholesale electricity market restructuring and competition in New England to be about 2% of wholesale costs. The SCBA methodology used in this study was based on Newbery and Pollitt (1997).

Likewise, Brunekreeft (2008) estimated the welfare impacts of ownership unbundling of the electricity transmission system operators in Germany using discounted SCBA. The results suggested marginal gain in terms of net weighted discounted benefits. De Nooij (2011) economically analysed the decisions to build the NorNed and the East-West interconnectors in Europe using a SCBA. The main conclusion from the analysis indicated that the current interconnector and transmission investment decisions in Europe are unlikely to maximize the social welfare. Malaguzzi Valeri (2009) analysed the effects of additional interconnection on welfare and competition in the Irish electricity market. The study found that the amount of interconnection with the Great Britain market would have to be large for the two markets to benefit from market integration. The study concluded that as the amount of interconnection increases, there are also positive effects on competition in Ireland, the less competitive of the two markets.

However, assessing the effectiveness of electricity reforms experience can be complex as it includes different interrelated steps. These can occur in different forms or models in a dynamic process (Pollitt, 2009). Electricity sector reforms are multi-dimensional activities with many interacting factors and a variety of impacts that a SCBA may inadequately capture. Hence, there exist other important applicable approaches to analyse electricity sector reforms and can be classified into four major categories:

econometric studies, efficiency and productivity analysis, macro studies and individual and comparative case studies. Econometric studies can suitably analyse well-defined issues and hypothesis tests through statistical analysis of reform determinants and performance while efficiency and productivity analyses are desirable for assessing the effectiveness with which inputs are transformed into outputs, relative to best practice. Macro studies of reforms estimate their impacts using general equilibrium models of the economy. Likewise, single or multi-country case studies are desirable when in-depth investigation or qualitative analysis is needed.

2.1. Econometric Studies

Econometric studies are used to examine the drivers of electricity reform and to quantify the effect of various reforms on the electricity performance indicators. Performance metric regressions based on cross-section and panel data econometrics are applied for this purpose. Statistical tests to assess the significant differences in the performance metrics before and after reforms are also applicable by conducting a t-test. However, a t-test for significant performance differences cannot control for the effects of other variables as in a multi-variate regression analysis. Several econometric studies have examined the effect of reforms on performance indicators in developing and developed countries based on regression analysis.

Ruffin (2003) conducted an econometric study of institutional determinants of competition, ownership and extent of reform as dependent variables in electricity sector restructuring using cross-section regression analysis for 75 developed and developing economies around the world. Different measures of judicial independence, distributional conflict and economic ideology were used as explanatory variables. The study found an ambiguous relationship between judicial independence and competition and ownership. However, greater distributional conflict is significantly correlated with a higher degree of monopoly while there was a positive but not always significant relationship between judicial independence and extent of reforms. Nagayama (2009) studied whether the effects of electric power sector reforms should be different either across regions or between developed and developing countries using panel data for 78 countries from four separate regions involving the developed, developing Asian, Latin American and selected transition countries around the world for the period 1985 to 2003. The results suggested that higher electricity prices was one of the driving forces for government to adopt liberalisation models while the development of liberalisation models in power sector did not necessarily reduce prices.

Similarly, Erdogdu (2011a) empirically analysed the impact of power market reforms on residential and industrial price-cost margins and their effect on cross-subsidy levels between different consumer groups using panel data for 63 developed and developing countries covering the period 1982-2009. The research findings suggested that there is no uniform pattern for the impact of the reform process as a whole on price-cost margins and cross-subsidy levels. Hence, each individual reform step has a different impact on price-cost margins and cross-subsidy levels for each consumer and country group. This also implies that reform prescription of a specific country cannot easily and successfully be transferred to another country. Another study by Erdogdu (2011b) analysed the impact of power market reforms and their effects on power sector efficiency using panel data from 92 developing and developed countries covering the period 1982-2008. The findings showed that income level and other country specific features are more important determinants of industry efficiency than reforms. The study concluded that introducing a decentralised market model with competition in the electricity sector has a limited increasing effect on electricity industry performance.

A number of studies have also examined the effects of various aspects of reforms on industry performance among the OECD countries. Steiner (2001) tested whether regulatory environment, degree of vertical integration and degree of private ownership have an impact on efficiency and on prices for a panel dataset of 19 OECD countries for the period 1987-1996. The study found that utilisation rate is positively and significantly correlated with both private ownership and unbundling of generation and transmission. The results also showed that private ownership is not necessarily correlated with increased competition while the establishment of a spot market was found to lead to lower prices. Hattori and Tsutsui (2003) replicated Steiner's model for the same sample of countries but for a different time period covering from 1987-1999 slightly changing the definitions of the regulatory reform indicators. The study found that the existence of a wholesale market is statistically significant and positive for prices while third party access is statistically significant negatively in contrast to Steiner (2001). This implies that precise definitions of reform indicators are critical to the empirical work undertaken. Meanwhile, Chang and Berdiev (2011) examined the effect of government ideology, political factors and globalisation on energy regulation in electricity and gas industries using a panel dataset for 23 OECD countries over the period 1975-2007. The study found that left-wing governments promote regulation in gas and electricity sectors while less politically fragmented institutions contribute to deregulation of gas and electricity industries. The findings from this study indicate that political economy factors are also important determinants of electricity sector reform and regulation in the advanced economies.

While the previous studies examined the impact of reforms on OECD countries, Bacon and Besant-Jones (2001) tested hypotheses on the determinants of reform for a sample of 115 developing countries using cross-section regression analysis for the year 1998. The results suggested that reforms are positively associated with country-level policy and institutions while reforms tend to occur with high probability in countries with lower political and economic risk. Zhang et al. (2005) studied the effect of sequencing of privatisation, competition and regulation reforms in electricity generation using panel data for 25 developing countries covering the period 1985-2001. The results from the study concluded that establishing an independent regulatory authority and introducing competition before privatisation is correlated with higher electricity generation and higher generation capacity while sequencing competition before privatisation significantly improves capital utilisation.

Another study by Zhang et al. (2005) provided an econometric assessment on the effects of privatisation, competition and regulation in electricity generation industry using panel data for 36 developing and transitional countries over the period 1985–2003. The study identified the impact of these reforms on generating capacity, electricity generation, and labour productivity in electricity generation and capacity utilisation. The results suggested that privatisation and regulation, on their own, do not lead to obvious gains in economic performance though there are some positive interaction effects. In contrast, introducing competition does seem to be effective in stimulating performance improvements. Sen and Jamasb (2012) also conducted an econometric analysis of the determinants and impact of electricity reform in India giving special regard to its political economy and regional diversity using panel data for 19 states spanning 1991-2007. The results showed that individual reform measures have affected key economic variables implying that the nature of reform in individual states would determine these economic outcomes. The findings suggest that outcomes have tended to be adverse in the initial stages of reform as previously hidden distortions become apparent in the reform process due to political economy factors in developing countries.

2.2. Efficiency and Productivity Studies

Efficiency and productivity studies use parametric and non-parametric methods to measure productivity and efficiency. Parametric methods of efficiency analysis rely on specified functional forms of production or cost functions and utilise econometric techniques. Typical parametric methods include regression analysis and stochastic frontier analysis (SFA). Non-parametric methods use mathematical programming techniques and do not require specification of production or cost functions. Data Envelopment Analysis (DEA) is a commonly used non-parametric method that evaluates performance relative to the frontier. Frontier methodologies do not assume that all economic agents are technically efficient and measures efficiency as the distance to the frontier by constructing a cost or production function. Therefore, each individual agent is benchmarked against the best practice. Such studies reduce the need for data and especially when the data is challenging to collect. A number of studies have analysed the effect of electricity reforms on productive efficiency in developing and developed countries.

Plane (1999) evaluated the impact of privatisation of Côte d'Ivorie Electricity Company (CIE) on efficiency using the SFA technique to measure efficiency change. The results obtained could not reject the hypothesis of a significant performance improvement in post-privatisation period while the technical efficiency measures have behaved irregularly since privatisation. Estache et al. (2008) first attempted at documenting efficiency levels in Africa's electricity firms based on a sample of 12 operators providing services in the 12 country members of the Southern Africa Power Pool. The study relied on the DEA decomposition technique to estimate the changes in total factor productivity (TFP). The results showed comparable levels of efficiency and performance levels in the region while finding no clear correlation of efficiency with the adoption of reforms.

A number of studies have also focussed on efficiency and productivity analysis of electricity reforms in the transition countries. Berg et al. (2005) analysed 24 electric utilities in Ukraine in determining the extent to which privately owned firms respond to incentives in ways that are different from publicly owned firms in the context of a new regulatory authority and distribution utility privatisations. The results from the empirical analysis suggested that a privately-owned firm responds to policies and incentives associated with reducing commercial and non-commercial network losses. Cullman and von Hirschhausen (2008a) tested the hypothesis that economic transition toward a market economy increases the efficiency of firms by studying 32 Polish distribution companies using the DEA and SFA techniques. The results illustrated that technical efficiency of the companies increased during the transition process while allocative efficiency deteriorated. Another study by Cullman and von Hirschhausen (2008b) provided a cross-country efficiency analysis of electricity distribution companies in the East European transition countries of Poland, the Czech Republic, Slovakia and Hungary using non-parametric efficiency measurement involving DEA. The results showed the Polish distribution companies to be inefficiently small while the Czech Republic featured the highest efficiency. Slovakia and Hungary occupied the middle range. This implies that privatisation had a positive effect on technical efficiency in all four countries.

A limited number of studies have been carried out to assess the efficiency and productivity of electricity reforms in developing Asian countries. Jain et al. (2010) evaluated the performance and efficiency of Indian electricity generation companies using both SFA and DEA approaches to analyse the effect of restructuring in the Indian electric power sector. The result supported the government policy of unbundling the Indian power sector. Wattana and Sharma (2011) examined whether electricity industry reforms improved the technical performance of the Thai electricity industry using DEA for the period 1980-2006. The study revealed that the increase in productivity of the Thai electricity industry over the period 1980-2006 was mainly driven by technological improvements and that industry reform had insignificant impact on productivity. Bautista et al. (2011) examined the efficiency and productivity of 120 electric cooperatives in Philippines using DEA for the period 2001-2006. The results showed that productivity in the sector had not improved significantly despite the reforms instituted in 2001. Nakano and Managi (2008) measured productivity in Japan's steam power-generation sector and examined the effect of reforms on the productivity over the period 1978–2003 using the DEA approach. The empirical analysis showed that regulatory reforms have contributed to productivity growth in the steam power-generation sector in Japan.

Similarly, Pardina and Rossi (2000) studied technical change in a sample of electricity distribution companies in South America involving 36 distribution companies from ten South American countries using the SFA technique. The results failed to reject the hypothesis of no change in inefficiency effects over the period 1994-1997 while there was only partial evidence of correlation between reforms and performance. Ramos-Real et al. (2009) estimated the changes in productivity of the Brazilian electricity distribution sector using DEA on a panel of 18 firms from 1998 to 2005. The results generally proved that the reform processes as well as the incentives generated in the reform process do not seem to have led the firms to behave in a more efficient manner. Perez–Reyes and Tovar (2009) assessed whether reforms have improved efficiency by analysing the evolution of productivity of 14 electricity distribution companies in Peru. The analysis suggested that improvements in efficiency and productivity of electricity distribution in Peru have occurred with the adoption of liberalised reforms in the Peruvian electricity sector.

In the context of developed countries, von Hirschhausen et al. (2009) applied non-parametric and parametric tests to assess the efficiency of 307 electricity distribution companies in Germany. The results suggested that only very small utilities have a significant cost advantage while East German utilities featured a higher average efficiency than their West German counterparts. Delmas and Tokat (2003) examined the short-term impact of supply deregulation on the productive efficiency of electricity utilities in the United States using DEA. The results supported the hypotheses that a greater level of deregulation leads to a lower level of technical efficiency in the short-term while there is a U-shaped relationship between the level of vertical integration and efficiency. Vaninsky (2006) estimated the efficiency of electric power generation in the United States for the period starting 1991 through 2004 using DEA. The results showed relative stability in efficiency from 1994 through 2000 at levels of 99–100% after which the efficiency declined. Hattori et al. (2005) examined the relative performance of electricity distribution systems between 1985 and 1989 in the UK and Japan using DEA and SFA methods. The results showed that productivity gain in the UK electricity distribution has been larger than in the Japanese sector while productivity growth accelerated in the UK under tightened revenue caps.

2.3. Macro Studies

A number of studies have attracted the use of general equilibrium models in assessing the quantitative impacts of electricity reforms on the economy. The computable general equilibrium (CGE) models use actual economic data to estimate how an economy might react to changes in policy, technology or other external factors. The advantage of the reform studies based on CGE modelling is that these studies attempt to model the interaction effects of sector reform with non-reforming sectors and calculate the aggregate welfare effect directly.

Whiteman (1999) evaluated the macroeconomic impact of microeconomic reform of the Australian electricity industry using a CGE model. The study estimated a 0.22% increase in the GDP in the long run as a result of the electricity reform. The benefits of the reform were reflected in terms of a rise in real wages rather than an increase in employment. A study by Copenhagen Economics (2005) estimated that liberalised reforms such as market opening in network industries including the electricity sector raised the GDP of the EU-15 by 2%. This study was a report prepared for the European Commission using CGE modelling.

In the Chinese context, He et al. (2010) estimated the impact of electricity price adjustment policy on the Chinese macro-economy based on a CGE model. The results concluded that an electricity price increase had an adverse influence on GDP, and the consumer price index (CPI) implying that electricity price increases have a contractionary effect on economic development. Kerkela (2004) estimated the costs of subsidised energy system in Russia and then analysed the government policy of boosting the gas and electricity prices to bring them into line with market-based pricing using a multi-region general equilibrium model. The results showed that energy subsidies extracted over 6% of GDP while increases of 6% in electricity and 10% in the price of regulated gas would improve economic efficiency by reducing subsidies distortions and distinctly shifting output from domestic markets to exports. Galinis and Leeuwen (2000) analysed the policy consequences of continuing with the future use of electricity generated from nuclear sources in Lithuania using a CGE model. The result showed that a low nuclear potential in Lithuania would result in low economic growth and development.

Similarly, a notable study by Chisara et al. (1999) estimated the macroeconomic and distributional effects of utilities privatisation and regulation in Argentina using a CGE model. The results showed that both privatisation and effective regulation led to significant macroeconomic benefits. However, gains from privatisation accrued mainly to high-income classes, while gains from the effective regulation of newly privatized utilities accrued mainly to low-income classes. The CGE estimates of overall employment effects suggested that privatisation was not a major contributor to the dramatic rise in unemployment in Argentina between 1993 and 1995. Boccanfuso et al. (2009a) used a CGE model to explore the distributional effects of price reform in the electricity sector of Senegal. The analysis demonstrated that poor and rural households were not the main beneficiaries of the expanded network while the results of the CGE model showed that direct price effects were weaker than general equilibrium effects on poverty and inequality. Another study by Boccanfuso et al. (2009b) explored the distributional and poverty-related effects of price reform in the electricity sector of Mali, a poor country in West Africa, using a CGE model. The results showed that direct price increases had a minimal effect on poverty and inequality, whereas the general equilibrium effects of such increases were quite strong and negative.

2.4. Case Studies

Qualitative aspects such as regulation and conflict resolution and reform dynamics such as the implementation process are crucial factors in assessing the efficacy of electricity sector reforms and processes (Jamasb et al., 2004). However, these factors are inherently difficult to capture through statistical methods. Case studies can examine the issues that do not easily lend themselves to rigorous quantitative analysis or could not be analysed due to lack of comprehensive data. Hence, analysis based on case studies can also overcome the issues associated with model specification and accuracy of variables in representing the relevant aspect of reform. Case studies involving single or multiple countries have been a popular technique to study the process and outcomes of electricity sector reforms in many developing and developed countries.

The assessment of reform performance across the reforming countries is based on the selection of performance indicators used for the comparative assessment of utilities as well as in gauging the impacts of sector reform on performance. Few notable studies have developed the indicators for power utility performance in developing and transition countries that are used in comparative assessment of reforms and in benchmarking studies. Jamasb et al. (2004) provided a framework for benchmarking and analysing the performance of utilities undergoing reforms in developing countries. The study proposed a set of core performance indicators encompassing the economic, social, technological and environmental aspects of power sector reform. A World Bank (2007) study identified the core indicators for benchmarking analysis of electricity distribution sector in the Latin American and Caribbean region. This study categorised the performance variables in terms of technical and operational, quality, access and financial. Another study in World Bank (2009) created the electricity sector database for Sub-Saharan African countries undergoing power sector reform. The study categorises the performance indicators as measures of technical efficiency, electricity coverage, electricity usage, supply quality, electricity pricing and financial efficiency. Since 1994, the European Bank of Reconstruction and Development (EBRD) has developed the transition indicators to assess the progress of reforms in all sectors of the economy including the power sector. The progress of reforms in the power sector is assessed under nine categories including ownership, independent regulation, vertical unbundling and cost-reflective tariffs.

Fisher et al. (2003) addressed the effect of privatisation of the Chilean electricity sector without vertical or horizontal unbundling on efficiency of firms and social welfare. The study found that privatisation led to rising investments in generation and transmission, falling unit costs, declining energy losses and increasing labour productivity. Pollitt (2004) assessed the progress of the Chilean electricity reform that began in 1982 using a case study approach. The overall experience showed that the success of private ownership and operation of the electricity industry in Chile provided a successful reform lesson to other developing countries. Similarly, privatisation of the electricity sector with full-scale vertical and horizontal restructuring led to increasing investments in generation, declining distribution losses and a reduction in the spot price of electricity in Argentina (Rudnick and Solezzi, 2001). Pollitt (2008b) also highlighted that liberalised electricity reforms in Argentina were very successful prior to the collapse of the Argentine peso in early 2002. However, the economic achievements of the sector have been severely constrained by the Argentine government's poor energy policy since the crisis. In Colombia, privatisation of the unbundled electricity sector and the introduction of bid-based pool market improved the quality of supply in the Colombian electricity market by reducing the average interruption time (Pombo and Taborda, 2006).

In India, unbundling and privatisation of some state electricity boards in 1991 contributed to declining distribution losses for Andhra Pradesh State Electricity Board and Delhi Vidyut Board (Bhatia and Gulati, 2004). However, Bhattacharya (2007), using an institutional economics framework, showed that the South Asian developing countries including Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka have not been able to make any noteworthy example of successful reform in the region since reforms started in 1990s. Slow progress of reform in these countries has affected the viability of the sector due to inadequate investment and poor operational performance. In Sub-Saharan Africa, reforms have involved the introduction of IPPs with some unbundling and limited progress in establishing independent regulatory mechanisms. This has resulted in addition of about 4 gigawatts (GW) of capacity since early 1990s with IPPs generally showing better technical performance than regions with state-owned incumbent utilities as observed in Kenya (Eberhard and Gratwick, 2011).

Similarly, Victor and Heller (2007) concluded that the actual application and success of the standard textbook model has been highly erratic while the experience of power sector reform in developing countries seems to have gone wrong after evaluating the reform experiences of Brazil, China, India, Mexico and South Africa. Williams and Ghanadan (2006) concluded that the non-OECD reform experiences suggest disappointing results due to the absence of effective regulation and socio-political legitimacy based on reform case studies of Bolivia, Ghana, India, Poland and Thailand. The reform process in the electricity sector of many transition countries not associated with the EU have also been heterogeneous and marked by political reluctance resulting in slow and stalled implementation of reforms (Kessides, 2012). There is wide variation in progress with the implementation of the model even in the EU while compliance with directives does not necessarily imply a thorough-going electricity reform (Pollitt, 2009). For example, Germany started the electricity market liberalisation process in 1998 without an independent regulator which was only created in 2005. The theoretical analysis by Pollitt (2009) also concluded that the transition countries can gain above costs of reforms from judicious combination of reforms in the electricity sector.

In the United States of America (USA), energy reforms affecting the electricity sector have been the most disappointing even though major progress has been made in removing the costly price and entry regulation affecting almost every energy sector directly or indirectly over the last nearly four decades (Joskow, 2009). Likewise, the UK reform experience has revealed considerable complexities and difficulties in making market driven reforms work to meet the climate change and security of supply targets (Pollitt, 2012). Nonetheless, reforms have progressed in Australia, Canada, the United States and parts of Latin America. Kessides (2012) concluded that the standard reform model with competition, unbundling and effective regulation can lead to large gains in performance when implemented properly.

The theoretical and empirical evidence suggests that reforms seem to have improved productive and operational efficiency in many developed and transition countries although allocative efficiency has deteriorated in the early reform process. However, it is not clear whether the gain in productive efficiency resulted from technological improvements or from the adoption of reforms. In many developing countries, reforms seem to be largely ineffective in inducing efficiency improvements with minimal or no effect on poverty and income inequality. Hence, the performance of reforms suggests that the success of market-based reforms is neither uniform nor guaranteed across the reforming countries. However, theoretical and empirical studies on the performance of market-based reforms on economies with small electricity systems are limited. Hence, clear conclusions on the performance of reforms in small electricity systems cannot be extracted. Likewise, the empirical evidence on the performance of electricity reforms in the context of wider macro-economic reforms is also missing in the literature. This thesis aims to fill in these gaps using both cross-country econometric studies and case studies to assess the effectiveness of reforms in the electricity sector of the reforming countries.

Chapter 3 uses a case-study approach to evaluate the performance of reforms in the Nepalese electricity sector. Nepal is a developing country in South Asia and has a small electricity system. This is the first study to thoroughly assess the performance of various electricity reforms in Nepal. Chapter 4 uses panel-data econometrics to evaluate the performance of electricity reforms in the transition countries. The size of the electricity sector among the transition countries vary from being small to large. This is the first study to quantify the performance effects of electricity reforms in the context of overall macroeconomic reforms in the transition countries. Chapter 5 uses time-series econometrics to analyse the performance of electricity reform policy aimed at deepening competition in the Irish wholesale market through increased interconnections. The wholesale market in Ireland can be considered a small system as compared to other wholesale electricity markets in Europe. This is the first study to quantify the effects of interconnections on market integration involving the Irish wholesale electricity market in line with the EU policy of increasing electricity market integration in Europe.

Chapter 3: Reforming Small Electricity Systems under Political Instability: The Case of Nepal

3.1. Introduction

Electricity sector reforms have remained a priority across many developing and developed economies since the late 1980s. Many advanced economies and developing countries introduced some market-based reform steps in their electricity sector by the end of 1990s. Countries in the South Asia, including Nepal, also initiated some reform of their power sector as the popularity of market-oriented electricity reforms grew around the world. However, the motives, ideology, and initial contexts of reform differed across these countries although the reform aspirations were relatively similar. In developed economies, improving economic and financial efficiency were the guiding principles of power sector reform. Reforms in less-developed countries were inevitable due to the burdens of price subsidies, low service quality, low bill collection rates, high network energy losses and poor service coverage experienced under the monolithic state-owned and controlled systems (Joskow, 1998; Newberry, 2002b; Kessides, 2004; Jamasb, 2006).

The initial context of reforms across the developed and developing reforming countries also varied in terms of institutional arrangements and frameworks, political ambience, market structures and electricity sector size and resource endowment. The electricity sectors of many developing countries, including Nepal, can be regarded as ‘small systems’. Small power systems are defined as having less than 1000 megawatts (MW) of installed capacity in a developing country context (Besant-Jones, 2006). As of 2004, 60 developing countries had peak system loads that were below 150 MW; another 30 countries between 150 and 500 MW, and possibly another 20 countries are between 501 and 1000 MW (Bacon, 1999). However, increasing population and load implies that many small power systems will not remain small and instead grow over time from their current size. As such, the peak load in Nepal is also projected to increase to 2206 MW by 2020 and to 3679 MW by 2030 (NEA, 2010).

Meeting the rapid growth in electricity demand remains a major challenge facing the Nepalese electricity sector. The vertically-integrated Nepalese electricity sector has managed to develop only around 0.72 GW out of potential 40 GW of generation capacity including those of the IPPs since the establishment of Nepal Electricity Authority (NEA) in 1985. Various factors have contributed to the slow development of hydropower in Nepal despite being endowed with large water resources (Joshi and Khadka, 2009). The sector evolved in the on-going governmental and political instability in the country while having experienced a major ‘civil war’ that spanned for eleven years. The ‘civil war’ or ‘Maoist insurgency’ lasted from February 1996 until November, 2006 and involved 14,000 losing their lives while making 150,000 homeless. The political leadership has changed around 15 times in the last decade with Nepal being the world’s most recent republic nation in 2008. NEA, operating under a single-buyer model (SBM), is also not immune to political intervention and corruption. Political instability has severely affected the predominantly state owned and controlled Nepalese electricity sector resulting in discontinued policies, uncertainty, and weak and often stalled implementation of sector reforms and policies. Thus, the current organisation and structure of the electricity sector can be regarded as uncertain and unsustainable considering growing political instability and rising electricity demand after more than two decades of the electricity reform process.

The purpose of this study is to assess the performance of the Nepalese power sector since the adoption of various reforms and policies after NEA was established. The contributions of this study are two-fold. Firstly, this study provides important electricity reform lessons for several monolithic state-owned and controlled ‘small electricity systems’ in Asia and Africa reeling under growing political instability and increasing electricity demand. Secondly, the study aims to fill an existing gap in literature regarding a comprehensive study of the power sector reform process and outcomes in the Nepalese electricity sector.

The study discusses international experience with electricity reforms in South Asian countries where reforms began often under external insistence but did not produce any example of successful reform in the region (Bhattacharya, 2007). In contrary, successful electricity reforms in several Latin American countries (LACs) such as Chile, Argentina and Brazil are also discussed. These LACs successfully reformed from having a small power sector towards a large one in the last two decades since adopting the market-based reforms. Chile, in particular, provides an intriguing case because it introduced market-based reforms in the electricity sector with a small system, weak rule of law and weak democracy (Jamasb et al., 2004). These conditions can be regarded as obstacles to liberal electricity reforms with private participation. However, the relative success of electricity reforms in Chile imply that the Chilean reform experience can be a useful guide on long-term performance of reform in developing countries. Thus, the lessons learnt from the successful international experience with reforms in countries like Chile provide a useful guidance to ‘small systems’ like Nepal whose electricity sector will have to grow under increasing population and economic growth.

The remainder of the chapter is organized as follows. Section 3.2 presents the economic arguments related to introducing market-driven reforms in small power systems. Section 3.3 briefly discusses the policy framework and institutional structure of the Nepalese electricity sector. The policy framework describes the contents of the major electricity reform initiatives in Nepal after 1990. In Section 3.4, the major economic, operational and environmental consequences of power sector reforms from 1990 till 2008 are evaluated. Section 3.5 discusses the role of political instability in affecting the process and outcomes of electricity reforms. Section 3.6 discusses the multi-stage reform options addressing the concerns of high political volatility and growing electricity demand. Section 3.7 concludes the chapter and offers some policy recommendations.

3.2. Reforming Small Electricity Systems

One of the hallmarks of the electricity reforms in Chile and Argentina was the vertical and horizontal separation of the electricity sector coupled with large scale privatisation based on the textbook reform model (Pollitt, 2008a). The aim of vertical unbundling is to separate the potentially competitive generation and retail supply from the natural monopoly activities of transmission and distribution networks (Meyer, 2011). In principle, vertical separation facilitates introduction of competition in wholesale and retail markets and leads to cost-reflective pricing, prevents cross-subsidy, reduces downstream foreclosures, improves cost and overall transparency in network and competitive business and removes the incentive for third-party and non-price discrimination (Rey and Stiglitz, 1988; Brunekreeft, 2008).

However, small systems are characterised by small size and low load density of the market which suggests that the benefits of vertical separation are difficult to realize in small markets. The small size of the market limits the effectiveness of competition in wholesale market as only a limited number of generating companies can be supported leading to oligopolistic market situations and can be susceptible to market power (Domah, 2002). This implies that the benefits of full sector restructuring and reforms may be small in relation to the costs considering the limited scope for competition and scarce managerial expertise in developing countries with small electricity systems. Thus, the benefits of competition arising from vertical separation of the networks as well as economies of scale can be limited in small power systems like Nepal.

In addition, important technological aspects of electricity supply favour vertical integration between different supply stages resulting in vertical scope economies. The benefits of vertical integration can be significant in terms of coordination economies, market risk economies including hold-up risks and specialisation economies (Kwoka, 2002; Meyer, 2012). Further, bundling small companies under a monopsony regime via a SBM can allow vertically integrated small system to benefit from economies of scale. Hence, competition arising from vertical separation may not be feasible and, if feasible, may not be desirable and effective in small systems. However, unbundling can be more cost-effective in these systems if other restructurings are taking place or the initial ownership structures are not costly to change (Pollitt, 2008b).

Thus, the choice between vertical integration and unbundling is between the economies of coordination and scope on the one hand with possible increases in transactions costs and the potential efficiency gains from competition and increased efficiency across small systems on the other (Klass and Salinger, 1995). From an economic welfare perspective, the productive and allocative efficiency gains from effective competition in conjunction with the distributional equity concerns needs to be carefully weighed against the benefits of economies of vertical integration in small systems. The transaction costs of full unbundling of small systems may exceed the subsequent efficiency gains. As the system grows over time, the efficiency gains and the effectiveness of competition from vertical separation can surpass the transactions costs. Hence, the relative merits of vertical separation can vary across different systems and should be judged cautiously in every case (Pittman, 2003).

Lessons from Chile and Argentina portray that careful regulation is essential under both vertically integrated and unbundled electricity industry structure. Unbundling may imply fewer activities to be regulated but it also makes the system more sensitive to regulatory practice. However, the implementation of an effective regulatory process is difficult and costly because of information asymmetries (Joskow, 1991). The incentive regulation of electricity networks under fast growing demand can also be a complicated and difficult task for the regulator. The absence of mature, well developed networks and regulatory agencies combined with high investment requirements in networks can limit the potential gains from unbundling the small electricity systems. Hence, the cost of regulation in vertically integrated small systems can be significant compared to the benefits (Kessides, 2004).

However, many developing countries, including Nepal, reforming their small electricity sectors lack the necessary experience and skilled human resources which can limit the scope and potential effectiveness of the electricity regulatory agencies (Domah et al. 2002; Pollitt and Stern, 2010). This is a major problem as the need to achieve minimum efficient scale for a regulatory agency may imply a large number of highly skilled staff relative to size of the electricity sector in small developing countries. A resistant political and administrative culture under an unstable political environment also implies that effective regulation under fragile institutional arrangements is difficult to achieve in naturally monopolistic small systems. The small electricity systems in Nepal and other South Asian countries suffer from inefficiency and institutionalized corruption and persistent rent seeking behaviour together with poor economic governance of the power sector (Smith, 2004). The regulatory agency is not independent from political intervention. Thus, appropriate governance structures and institutional arrangements are important factors to ensure independent regulation necessary to implement market driven electricity reforms in small electricity system like Nepal.

3.3. Policy Framework and Institutional Structure

The theoretical guiding principle for reforms in the Nepalese electricity sector is to enhance social welfare by efficient management of the available scarce resources (NEA, 2010). A large un-utilised capacity combined with increasing demand for electricity justifies the economic logic of exploiting the benefits of competition and economies of scale through electricity reforms in Nepal. Thus, a sequence of market-driven electricity reform initiatives was mooted after the formation of Nepal Electricity Board and Small Hydro Development Board in 1975. A classification system of hydro projects was established in 1975 followed by the creation of Nepal Electricity Act in 1984. In 1985, NEA was formed by merging the Electricity Department, Electricity Boards and Nepal

Electricity Corporation in accordance with the provisions of NEA Act of 1984 (Thakur, 2002). The establishment of NEA eventually paved the way towards creating a legal framework and corporatisation of the power sector through the formulation of the hydropower development policy of 1992 and was enforced by the Water Resources Act and the Electricity Act with amendments made to the NEA Act of 1984 as discussed below (ADB, 1999).

i) The objective of the *Hydropower Development Policy of 1992* was to promote and facilitate hydropower development allowing for state, joint sector (public and private) and private sector development of hydroelectricity projects through licensees. The policy emphasised intensifying national electrification through small hydro plants and mass capacity installation with the necessity to extend the distribution system to rural areas. The importance of foreign and private investment in the hydropower sector was recognised by allowing foreign investors to finance up to 100% capital investments. The implementation of the act meant the need for an appropriate legal framework supported by more acts (NEA, 2010).

- The *Water Resources Act of 1992* provides appropriate legal arrangements for utilisation, conservation, management and development of both underground and surface water resources in Nepal.
- The objective of the *Foreign Investment and Technology Transfer Act 1992* was to promote and facilitate economy-wide foreign investment and technology transfer by making optimum use of natural and human resources in the transition towards industrialisation.
- The *Electricity Act 1992* was primarily promulgated to promote private participation in hydro power development. It provides for exemption of licences for any individual or corporate body undertaking generation, transmission and distribution up to 1000 kilowatt (KW) capacity. Obtaining a licence was made obligatory for any capacity above 1 megawatt (MW) in the electricity industry but geographic monopoly could be retained in the licensee distribution service area with third-party entry possible under conditions of unsatisfactory performance of the licensee. The Electricity and Tariff Fixation Commission (ETFC) was established and NEA was made a licensee. The ETFC consisted of six persons and included a chairman chosen by the government from the non-governmental sector, a representative of the government from the Ministry of Energy (MOE), an economist prescribed by the government from the non-

governmental sector, a representative among the licensee of electricity generation, transmission or distribution and a representative each from the industry and consumer groups. NEA was required to act as a single-buyer via bulk-buying of power from generators at a purchase price sufficient to cover total investments in approximately 25 years after accounting for depreciation costs. The licensee also allowed the export of electricity subject to the payment of the export duty.

- The need to establish fair and competitive industrial arrangements meant the formulation of the *Industrial Enterprises Act 1992* with a view to create a congenial, straight-forward and encouraging industrial investment environment.

ii) The *Hydropower Policy of 1992* was revised in 2001 as the *Water Resource Development Policy*. The major objectives of the *Water Resource Development Policy* are to develop hydropower resources at economically efficient costs, to harmonise electrification with economic activities and to develop hydropower for export. The policy prioritises hydropower capacity expansion by attracting more domestic and foreign investments. The policy also led to the creation of certain institutional arrangements in particular by inducting the ETFC to the regulatory body. These enterprise levels restructuring at NEA implies that the Nepalese electricity industry currently runs under five core business groups for generation, electricity transmission and system operation, distribution, electrification and engineering services.

iii) The *Community Electricity Distribution Bye Laws* were introduced in 2003 with the objectives of promoting public participation in reducing non-technical power losses such as electricity theft and institutionalising distribution and encouraging community management in the extension of distribution lines through the distribution institution. The community electrification concept was introduced and regulation was passed for rural electrification. The community was also made responsible for distribution and sales of electric energy alongside NEA.

iv) The *Subsidy Development Mechanism* was introduced in 2006 with the aim to ensure a fair disbursement of subsidy in a cost effective and easy access manner. Similarly, the rural energy policy (REP) was established in 2006 with the overall goal to contribute to rural poverty reduction and environmental conservation by ensuring access to clean and reliable energy in rural areas. The policy emphasised the promotion of renewable energy technologies and decentralised power production models for intensifying rural electrification in Nepal. The REP also provided a framework for the establishment of the rural electrification board (REB) in Nepal.

Table 3.1 shows the timeline of major reform introduced in the Nepalese electricity sector.

1992	2001	2003	2006
Hydropower Development Policy 1) Water Resources Act 2) Foreign Investment and Technology Transfer Act 3) Electricity Act 4) Industrial Enterprises Act	Water Resources Development Policy	Community Electricity Distribution Bye Laws	Subsidy Development Mechanism

Table 3.1: Timing of major electricity reforms in Nepal

Source: Adapted from NEA (2010)

Hence, it can be inferred that the objectives of various electricity reform measures in Nepal are:

- to attract foreign and domestic private investment,
- to promote efficiency, fairness and economic principles in managing the sector and thereby reducing the dependence on state support,
- to rationalise and institutionalise sector activities through appropriate measures for the overall development of the sector, and
- to strengthen quality of supply at an affordable cost to consumers while allowing utilities to sufficiently recover their costs.

However, the electricity sector in Nepal is governed and influenced by a multitude of institutions as illustrated under Figure 3.1. The Department of Electricity Development (DOED) under MOE is responsible for implementing overall government policies related to the electricity sector by ensuring transparency of the regulatory framework while promoting and facilitating private sector participation in the power sector. NEA is responsible for generating, transmitting and distributing adequate, reliable and affordable electricity by planning, constructing, operating and maintaining all generation, transmission and distribution facilities in both interconnected and isolated system areas. The management of NEA is entrusted to a Board of Directors which represents all major stakeholders of the power sector. Likewise, the Water and Energy Commission Secretariat (WECS) formulates and assists in developing policies and strategies in the water resources and energy sector while also acting as a documentation centre for all regional water resources and energy related issues.

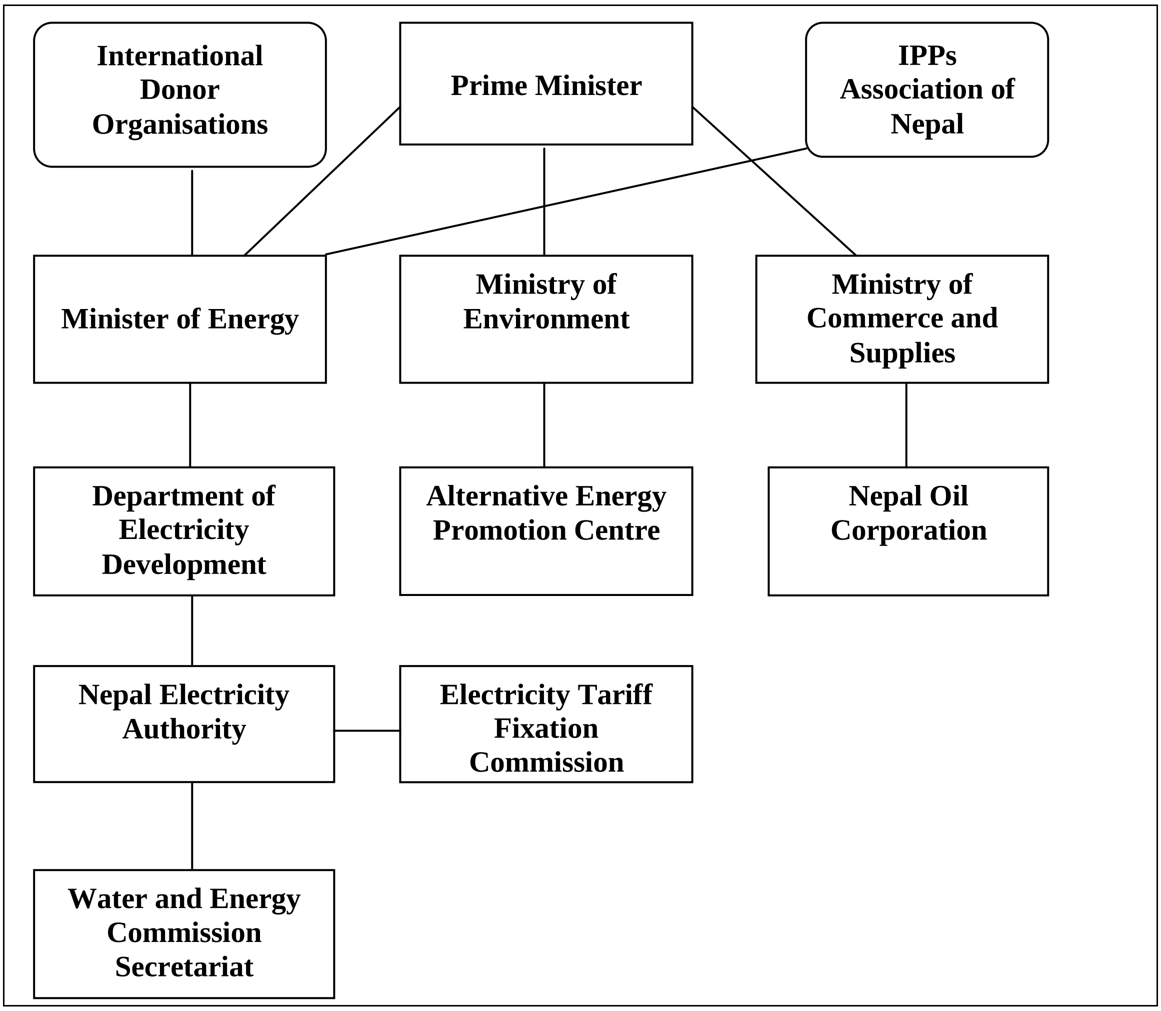

Figure 3.1: Institutional structure of the Nepalese power sector

The Ministry of Environment (MOEN) is responsible for the development of policy environment conducive to sustainable development through sustainable use of natural resources, promotion of sustainable practices and technologies and management of climate change induced risks. MOEN also looks after the development and promotion of micro-hydro technology in Nepal. The Alternative Energy Promotion Centre (AEPC) was established in 1996 to promote rural electrification using renewable technologies under MOEN. The formulation of the Subsidy Development Mechanism in 2006 has heightened the role of AEPC towards rural electrification and energy efficiency while the Nepal Oil Corporation (NOC) under the Ministry of Commerce and Supplies (MOCS) deals in all activities related to the imports of petroleum products in the Nepalese economy.

The Independent Power Producers Association of Nepal (IPPAN) was established in 2001 and is a non-profit, non-government and autonomous organisation. The role of IPPAN is to encourage the private sector to get involved in the development of hydropower in Nepal while also acting as a link between the private sector and government organizations. Thus, IPPAN is a lobbying organisation representing the private sector involved in hydropower development in Nepal. Similarly, international donor organisations have played an influential role in the development of Nepalese power sector as the sector has been receiving substantial technical and financial assistance since 1983 (UNDP, 1983). India, China, UK, USA, Germany, Japan, Switzerland and Canada have been the major bilateral donors. The multilateral donors have included organisations like the Asian Development Bank (ADB), the World Bank and the United Nations Group. The financial assistance from multilateral donors mostly involves loans as opposed to grants and comes with certain strings attached such as direct policy lending. For example, the formation of the Hydropower Development Policy in 1992 coincided with the Power Sector Efficiency Project grant by the World Bank.

Hence, power sector investments in Nepal are largely donor driven with significant influence of the donor organisations towards policy making in the power sector. The state or the ruling government dominates the institutional environment and institutional arrangements in the power sector while there is little representation of other stakeholders such as the consumer and industrial groups.

3.4. Performance of the Nepalese Electricity Sector

This section analyses the performance of the Nepalese power sector by studying the economic, operational and environmental aspects of electricity sector bearing important social welfare impacts. The reform outcomes discussed below will provide a basis to gauge the success of the power sector reform program over more than 20 years of reform.

<u>a) Prices</u>: Electricity prices in Nepal have been historically too low to cover costs and prices have not changed since the last decade. Power prices are not based on economic principles and are influenced by vested interests and political motives. Electricity is supplied to customers at highly subsidised rates creating distortions in demand. For

example, the charge per KWh of electricity supplied to a community wholesale consumer in 2010 was 3.5 Nepalese Rupees (NRs) while a small industry paid NRs. 6.60 per KWh of electricity consumed. Thus, cross-subsidization prevails in the Nepalese electricity sector. Figure 3.2 shows that the residential sector comprising 95.5% of the total electricity consumers accounted for 42% of overall revenue collection of NEA while the industrial sector consisting only 1.7% of total electricity consumers contributed 35% towards NEA's total revenue in 2008/09 (NEA, 2009).

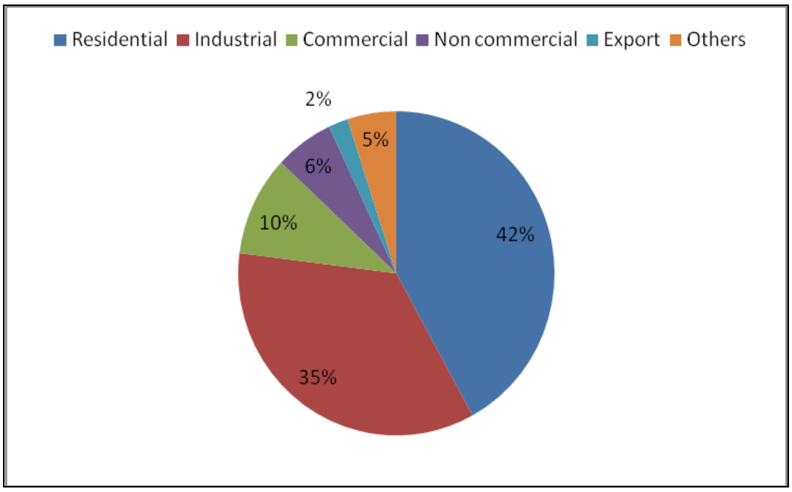

Figure 3.2: Contribution of consumer groups to total revenue

Source: Adapted from NEA (2009)

The NEA has a revenue rate of NRs 6.71 per KWh of electricity against the cost price of NRs. 9.05 per KWh (including transmission and distribution charges) of electricity. The under-pricing of electricity after accounting for a miscellaneous NRs. 0.43 of income per KWh of electricity imply that NEA suffered a loss of NRs. 1.91 per KWh of electricity in 2009 (NEA, 2009). The price-cost gap has exacerbated the poor financial health of NEA with an overwhelming loss of NRs. 4681 million in 2009 (NEA, 2009). NEA also maintains a discriminatory power purchase agreements (PPA) policy among domestic and Indian companies. The Nepalese IPP's are paid NRs. 6.5 per KWh of electricity while the Indian IPP's are paid NRs. 10.72 per KWh as an incentive to attract more foreign investment in the power sector.

b) Investment in generation: Underinvestment in generation is a major problem facing the Nepalese electricity sector even though investments have risen at a slow pace since 1983. The Nepalese electricity sector had 138 MW of installed generating capacity at the end of 1982 of which 11 MW was privately owned while the rest was government developed hydro with a modest amount of thermal (UNDP, 1983). However, lack of investment in the generation segment implies that Nepal has only been able to currently utilise about 1.7% of its technically and economically viable hydro-electric potential capacity. A fundamental reason for under-investment is low power tariffs which are not sufficient to support the system-cost and capacity expansion.

Figure 3.3 shows that hydroelectricity (owned by both NEA and IPP) is the dominant source of electricity generation in Nepal. The investments in hydro capacity accelerated post 2001 after the establishment of IPPAN and slowed down after 2003 primarily due to widespread national insecurity as the Maoist war intensified. The termination of war after November, 2006 led to increased investments in generation which emphasises the importance of political stability in the electricity sector. The capacity shortage in generation was apparent when projected demand for electricity surpassed 970 MW given an installed capacity of about 700 MW creating a severe power shortage in 2009. The peak demand is expected to reach 1700 MW by 2015 with additional capacity expansion of 170 MW by 2012 to be achieved (NEA, 2010). The projects to be completed include Chameliaya Hydroelectric project (30 MW), Khulekhani-III hydro project (14 MW), Trishuli 3-A project (60 MW), Rahughat hydro project (30 MW) and Upper Modi (40 MW).

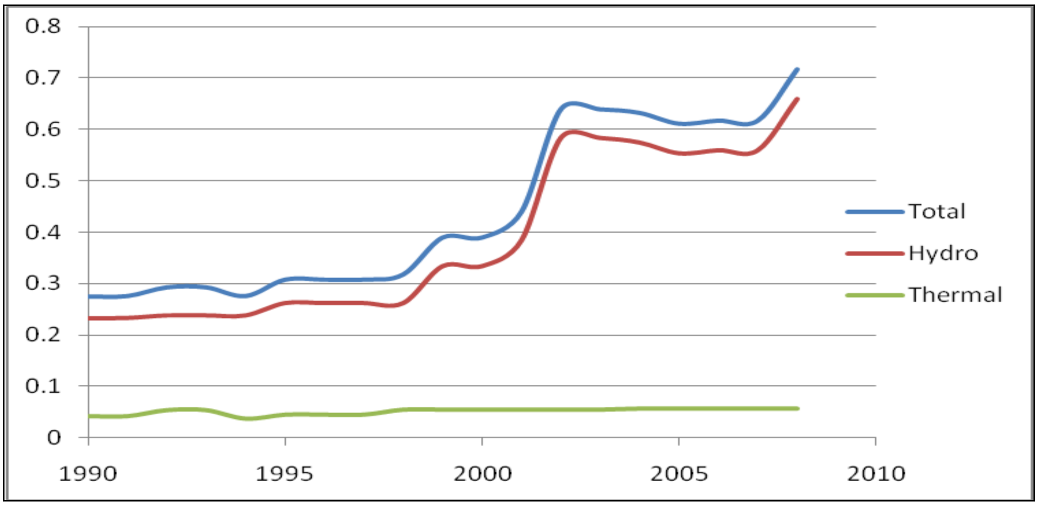

Figure 3.3: Total installed capacity by technology type (**in GW**)

Source: Adapted from EIA (2010)

The domination of hydropower also implies that renewable energy is the main source of power production in Nepal with thermal sources (especially diesel generation) contributing marginally. Nepal also solely imports 1.2 million tonnes of petroleum products from India as the country is devoid of any refining capacity (NOC, 2010). The demand for petroleum products is also expected to increase by 20% on an annual basis. Higher prices of petroleum products coupled with vulnerability in petroleum supplies have reduced the scope of adding capacity based on diesel sources. Coal imports have gone up due to liberal imports policy through license waivers on imports (Pokharel, 2007). However, this policy has had limited effect on thermal capacity additions as no significant new thermal capacity addition was added after 2000. A high reliance on hydropower and imported fuels indicates that the Nepalese electricity industry exhibits high security of supply risks.

c) Technical Network Energy Losses: The quality of power supply has been historically poor in Nepal and the inefficiency shows no signs of improvement. The power sector has been plagued by high technical and non-technical losses over the years. In 1979/80, overall technical electricity losses accounted for 31% of total power generation and increased to 35.7% in 1983/84 (Sharma, 1988). However, the technical losses during the last decade stood around 20% on average as observed in Figure 3.4. The losses reached a record level of 24% in 1997 which marked the initial phases of Maoist insurgency and have decreased since then.

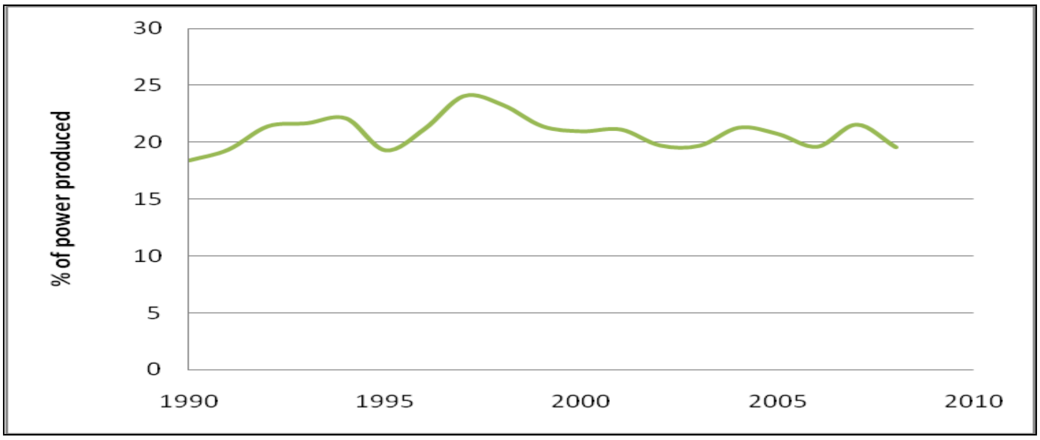

Figure 3.4: Electricity Distribution losses 1990-2008

Source: Adapted from EIA (2010)

The high level of technical losses in distribution can be attributed to old grids that are in need of investment for maintenance and upgrade. The high technical losses also imply that system reliability is low with frequent unplanned power outages. Grid expansion has also been slow in Nepal while lack of transmission and distribution facilities is a major bottleneck for generation capacity expansion in the country. The politically determined low prices have barred the sector from generating adequate revenue to finance additional network expansion. The country currently has 1,980 km of transmission lines and among the major transmission lines under construction are the 85 kilometer (km) Marshyangdi-Kathmandu 220 kilovolt (KV), Khimti-Dhalkebar 220 KV line (75 km) and Tamakoshi-Kathmandu 220 KV line (80 km). Insufficient transmission capacity led to 28 system collapses throughout 2010 due to congestion (NEA, 2010). There are currently 34 Distribution Centres and 37 Branch Offices of NEA spread over 49 out of 75 districts in Nepal.

d) Non-technical losses: Non-technical electricity loss in the form of theft is a grave issue in many developing countries including Nepal. Non-technical electricity losses arising from power theft is common across poor residential areas in South Asia where consumers do not have the ability and willingness to pay for electricity connection and energy usage. For instance, the army in Pakistan found 10,093 instances of power theft and recovered 2.4 billion Pakistani Rupees in fines and penalties in 1998 (Rizvi, 2000). It was estimated that electricity theft in Bangladesh was 14% out of 35% of total transmission and distribution (T&D) losses in 2003 (Smith, 2004). Lost earnings from power theft result in lack of profits and a need to expand generating capacity to offset the impact of power losses under investments crunch. The bourgeoning financial loss of NEA discussed above can be attributed to the high levels of electricity theft in the country resulting in lost earnings to some extent.

e) Rural Electrification: Rural electrification is one of the major energy policy goals in Nepal as in other South Asian countries. However, the electrification rate remains low in Nepal. Electrification rate is defined as ‘the number of people with an electricity connection in their home as a percentage of total population’ (IEA, 2012). Table 3.2 shows the electrification rates in 6 SAARC countries in 2009. Sri Lanka has been relatively successful in catering electricity to the rural sector which has translated into an overall high score in Human Development Index (HDI). HDI measures the strength of human capital in a country based on a comprehensive set of different categories. Electricity access and consumption is crucial towards human development in less-developing countries (Pasternak, 2000). Thus, the low levels of electrification in Nepal also imply a low level of human development in the country.

Country	Electrification rate (%)			Population without electricity (millions)	Energy Development Index (EDI)	Human Development Index (HDI)
	National	Urban	Rural			
Afghanistan	15.6	22	12	23.8	na	0.349
Bangladesh	41	76	28	95.7	0.169	0.469
India	66.5	93.1	52.5	403.7	0.272	0.519
Nepal	43.6	89.7	34	16.5	0.107	0.107
Pakistan	62.4	78	46	68.4	0.281	0.281
Sri Lanka	76.6	85.8	75	4.7	0.277	0.658

Table 3.2: Electrification status in 2009

Source: Adapted from International Energy Agency (IEA, 2012)

The rate of electrification increased from around 30% in 2005 to 43.6% in 2008 (IEA, 2012). However, electricity access is largely centralised among the urban population across South Asia including Nepal. Factors such as finance, governance, industrial organisation and policies can account for varying pace of electrification across much of the under-developed countries (Eberhard, 2004). The absence of proper electricity distribution infrastructures has delayed the process of rural electrification in the country. The difficult geographical terrain and lack of incentives such as low power prices has meant that the private sector is not willing to undertake the costly grid expansion in the country. In 2005, 78% of energy consumption was met through fuel woods while the residential sector was responsible for 90% of overall energy consumption in the country (Bhandari and Stadler, 2011). Thus, fuel woods are the dominant form of traditional and non-commercial energy source in Nepal.

A major reason for low Energy Development Index (EDI) of Nepal could be because energy consumption from fuel woods is not included in such calculation. EDI allows understanding the role played by energy in human development. The components of EDI are per capita commercial energy consumption, per capita residential sector electricity consumption, share of modern fuels in total residential sector and share of population without access to electricity (IEA, 2012). Absence of rural electrification leads to an increasing pressure on forests (the natural source of carbon storage) for fuel woods. Nepal (2012a) argues that decentralised renewable energy technologies can provide suitable opportunities to electrify rural areas in less developed economies like Nepal as these technologies are capable of making better use of the locally available resources. However, the development of renewable energy sources can be difficult to achieve in the absence of proper financial, institutional and entrepreneurial support.

f) Energy Trade: Reliable energy supply is necessary for stimulating economic growth in Nepal (Dhungel, 2008). Hence, electricity trade is a vital component of Nepalese economic growth plans. The dominant share of hydro power in generation and a poor energy capacity mix means that the sector is prone to electricity supply shortage during drought seasons. The geographical location also precludes the possibilities of interconnection with other power grids for a land-locked mountainous country like Nepal where connection to the Chinese grid is not possible due to difficult geographical terrains.

Nepal is engaged in a bilateral power trade with India mostly involving imports as the country is unable to utilise its hydroelectricity generation potential. India is the monopoly supplier (and a monopsony buyer) of Nepalese electricity. Thus, NEA is obliged to import electricity from India at a significantly higher price than paid to the domestic producers to satiate the increasing domestic electricity demand. The Nepal-India power trade is limited to an interconnector capacity of 100-150 MW with Nepal on the net importing side. The increasing reliance on imported electricity from India has heightened the security of supply risks from import dependency. However, the potential economic benefits from electricity trade to Nepal can be significant in the future as the energy intensive India with a fast growing economy has decided to import a minimum of 10,000 MW by 2020 from South Asian countries. This will require additional investments in expanding interconnector capacity between the Indian and Nepalese power markets.

g) Energy Intensity: Energy intensity is defined as the 'energy use per unit of GDP' and is a macro-level measure of the national energy efficiency. The energy use per unit of GDP is increasing in Nepal after 1990. The increase in energy consumption is due to an expansion in the residential and industrial customer base. Figure 3.5 (a and b) shows the curves for energy intensity, GDP and population growth rate. The fluctuating curve in figure 3.5 (b) is the mean stationary GDP growth rate and the steadily declining curve is the population growth rate. The figures reveal that increasing trend in energy intensity is spurred by an increase in overall GDP growth rate although the population growth rate has slowed down over the years.

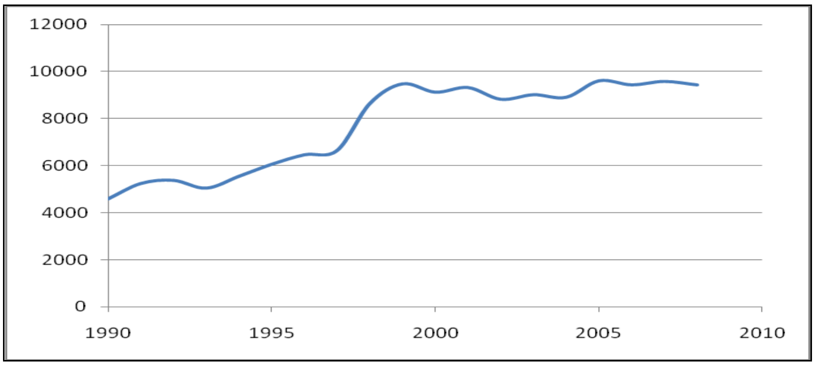

Figure 3.5(a): Energy intensity **(in Btu per year 2005 USD)**

Source: EIA (2010)

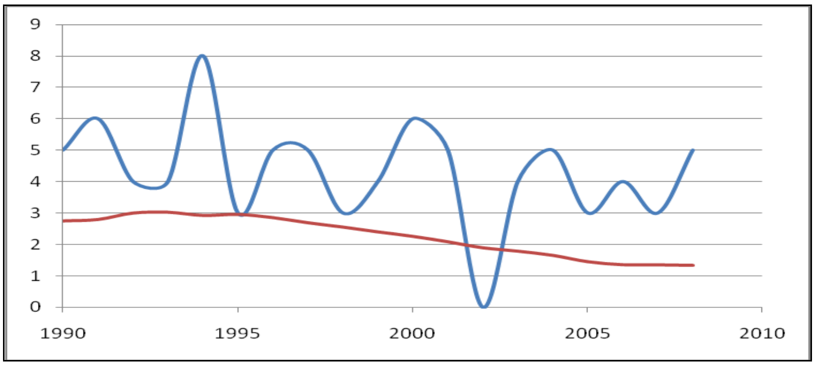

Figure 3.5(b): GDP and population growth **(in percentage)**

Source: EIA (2010)

The fall in GDP growth rate is also marked by a fall in energy intensity for respective years emphasising the critical role of energy consumption in economic growth. In recent times, GDP growth and energy intensity are not symmetrical due to insufficient energy available in the country. On the other hand, the absence of any appropriate demand-side management (DSM) policies means that available energy is not used efficiently.

3.5. Role of Political Instability in Reform Performance

The empirical evidence of power sector performance starkly defies the logic of power sector reforms in Nepal. The performance of the vertically-integrated Nepalese power sector resembles the conventional problems of a monopolistic public utility suffering from chronic underinvestment and insufficient capitalisation, politically determined low and distorted tariffs coupled with poor operational and financial performance as reflected in various studies (Munasinghe, 1992; Schram, 1993; Jamasb et al., 2005). The findings confirm that distorted electricity tariffs, low access rate, frequent supply interruptions, underinvestment, and inefficiency in operation are the trademarks of the

Nepalese electricity sector along with other South Asian countries such as India, Pakistan, Bangladesh, Bhutan and Sri Lanka (Bacon and Besant-Jones, 2001). Thus, the current performance of the sector has belied the theory behind market-based reform of the Nepalese electricity sector.

Political instability is one of the major reasons affecting the performance of electricity sector reforms and policies in Nepal. Several South Asian countries including Nepal experienced political instability which directly affected the traditional state-owned utilities under political control during the 1990s. Political instability disrupted the gradual implementation of the power sector policies and the reform objectives are still far from being achieved (NEA, 2010). Persistent political instability, infighting and power struggles, corruption, inadequate social and economic benefits and weak governance in Nepal contributed to a loss of confidence in government and the political system since the restoration of democracy in 1991 (ADB, 2004). As such, urgent issues such as poverty, utilities reform and rule of law took a backseat and remain unaddressed. The unstable political context halted the flow of domestic and foreign investment in the electricity sector. Likewise, international agencies such as the World Bank and ADB also did not commit any resources to the ‘aid’ dependent Nepalese electricity sector in the period of insurgency.

Political instability and changing priorities of successive governments have resulted in ‘almost-ready’ decisions being repeatedly rehashed in the Nepalese power sector (Krishnan, 2007). An example of the effect of policy discontinuity and changes in political leadership was exposed when the newly formed government in March, 2011 declared that ETFC will be dissolved. Political instability has opened up new opportunities for unfair rent seeking and corruption leading to rampant licensing and approving unfeasible projects, signing of loss making power purchase agreements with the private sector and undertaking socially unfair activities at the cost of state utility for electoral and political purposes. Persistent political instability can also place practical constraints on timeframes for undertaking reforms as any reform that extends beyond the lifespan of the government becomes politically infeasible and slows down or stalls the reform progress as a whole (Bhattacharya, 2007). For instance, the 2004 election in Sri Lanka elected new members of Parliament who opposed the restructuring and privatisation of the power sector and thereby halted reforms. Likewise, the state of

Haryana in India missed some crucial reform milestones after a change of government in 1999 with similar trends observed in Bangladesh and Nepal.

<table>
<tr><td rowspan="4">Political Objectives</td><td colspan="3">Political Environment</td></tr>
<tr><td>Type</td><td>Stable</td><td>Unstable</td></tr>
<tr><td>Temporary</td><td>Quick short-term fixing</td><td>Rent seeking, opportunism and milk-skimming</td></tr>
<tr><td>Long-term</td><td>Major sustainable reforms possible to undertake</td><td>Any reforms highly unlikely to be successful</td></tr>
</table>

Table 3.3: Reform matrix

Source: Adapted from Bhattacharya (2006)

Hence, the most distinctive aspect of reforms in South Asian countries like India and Nepal is the struggle to achieve a framework that protects the sector from political instability and political influence (Sen and Jamasb, 2012). Political stability is essential because reforms imply changes in institutional environment and institutional arrangements while these changes can only sustain the stability of the rule-makers. The government is the influential rule-maker in the Nepalese context. Table 3.3 shows long-term political objectives such as major electricity reforms in a state owned and controlled system are likely to be pursued and successful under a stable political environment.

Political instability can also translate into short-term opportunism and corruption by special interests and at the expense of long-term objective of the sector leading to poor and unsustainable sector performance. Complicated and lengthy reforms are not likely to be initiated or to work under political instability. On the other hand, political reluctance to implement reforms can slow the progress of reforms as observed among some transition countries of Eastern Europe even though these countries are politically stable (Nepal and Jamasb, 2013). However, political instability is likely to continue in Nepal implying that the electricity sector will have to develop under unfavourable institutional environment and arrangements to achieve the long-term national economic objectives.

The current performance of the Nepalese electricity reforms can present a major setback for an economy in the lurch towards an export-led economic growth. The annual energy demand is also expected to increase from 3859 GWh to 9563 GWh from 2009 to 2020 while the country continues to experience political uncertainty (NEA, 2010). Thus, reforming the power sector by considering the increasing political volatility and escalating energy demand is crucial for a country such as Nepal experiencing wide-reaching economic and political changes.

3.6. Reform Options for Small Electricity Systems

The state-owned and politicised power sector reform in developing countries with small systems has been a difficult, complicated and an unsuccessful process (Williams and Ghanadan, 2006). Chile and Argentina pursued the deepest and most radical reforms as their electricity sector grew while electricity reforms in Brazil were more cautious and gradual with almost a textbook approach (Dutta and Menzes, 2005). Mexico, on the other hand largely maintains vertical integration in the power sector while allowing private generators to participate in new capacity additions as in the Nepalese context (Rossellon and Halpern, 2001). Lessons from Brazilian electricity reforms suggest that creating a competitive market in the short-run can be difficult in a concentrated market when almost 90% of the electricity is hydropower as in Nepal (Schaeffer and Salem Szklo, 2001). This is because hydropower technology implies production conditions characterised by large economies of scale and therefore a regime close to that of a natural monopoly due to high minimum efficient scale of power generation (Gabriele, 2004).

The dependence on hydropower also means vulnerable supply and frequent blackouts during drought years. Hence, the reform options such as adjusting electricity prices and subsidies, independent regulation, restructuring, private sector involvement and reforms sequencing are equally important in the Nepalese context. The section below discusses some reform options for Nepal based on the experiences of electricity sector reforms of several countries that successfully transited to a larger system from a ‘small system’ accounting for political instability and increasing electricity demand. Moreover, these options can be of general relevance to other small power systems around the world experiencing rapid growth in demand and political instability.

3.6.1. Adjusting electricity prices and subsidies

In competitive electricity markets, prices convey correct market signals and carry appropriate informational efficiency as they reflect the actual cost of providing service as well as the long-run marginal cost of new capacity irrespective of the political environment. Economic theory also suggests that cost-reflective pricing is desirable as it leads to net social welfare gains although assessing the distributional impacts of tariff adjustment is a complicated task (Chang, 1997). However, the electricity prices in Nepal are below cost in order to maintain social peace as the government regulates the price. The inability of the sector to finance the system on its own due to underinvestment and growing losses of NEA indicate that adjusting electricity prices towards supply costs is necessary in a small system aiming to grow. A two part tariff design where a fixed payment is added to the system marginal income (such as capacity payments) can ensure the sustainability of the system as widely practised in most LACs. Cost reflective prices can also eliminate the system's deficit financed by the whole population and free up resources which can be used to improve access in poor and rural areas via electrification (Jamasb, 2006).

However, a tariff increase in Nepal also means debasing the economic welfare of an already poor population and hence is politically sensitive. Experience from Peru suggests that carefully designed targeted subsidies that address the undesirable social impacts while limiting the impact of price distortions can reduce the overall impact of price increases (Revolo, 2009). The reform experience in Chile also shows that a competitive allocation of government direct capital subsidy to private electricity distribution companies to cover some portion of the investment costs can be very successful in intensifying rural electrification. Hence, the state, private investors and all users contribute to funding rural electrification (Jadresic, 2000). Rural electrification rate in Chile is over 90% (Millan, 2007). However, competitive allocation of capital subsidies towards rural electrification in the Nepalese context requires the vertical separation and privatisation of the distribution sector. The experience with rural electrification in Thailand suggests that access to financial resources and capital subsidies were crucial in increasing the rural electrification rate from 7% in early 1970s to 97% by 2000 (Shrestha et al., 2004). A recent reform experience in Iran suggest that removing heavy subsidies on energy by introducing a direct cash compensation mechanism would lead to an efficient allocation of resources while improving social equity and income distribution (Guillaume et al., 2011).

However, utility subsidies have been poorly targeted in South Asia and have failed to reach the poor as shown by the Indian experience where only a quarter of one billion dollar subsidies for water services reached the poor households (Foster et al., 2000). Moreover, the use of targeted capital subsidies practice in Chile, Peru and Iran suggest that it is possible to strike a balance between economic efficiency and social equity in the Nepalese context by creating suitable institutional environment and arrangements surrounding the electricity sector. The electricity reform experience in Chile, Peru and Thailand also indicates that electricity access in developing countries can be improved by subsidising the capital costs associated with distribution network expansion in rural areas and recovering the operational costs from the sale of electricity at cost-reflective prices.

3.6.2. Independent and effective regulation

The widely used criteria in assessing the independence of a regulatory agency are the nature and terms of regulatory appointment, source of funding of the regulatory body and the extent of participation of the regulators in designing regulatory content such as tariff methodology (Stern 1997, 1998). This implies that the introduction of independent regulation in 1994 with the establishment of ETFC cannot be considered to be independent in Nepal. This is because of the political nature and terms of regulatory appointment, public source of funding of the regulatory body and low participation of the politically unaffiliated regulators in designing regulatory content such as tariff methodology (Stern, 1997). Hence, governance improvements and strengthening regulatory arrangements are necessary for small systems like Nepal to effectively implement electricity sector reforms and control corruption. Lessons from the Asian financial crisis underscored the need for a properly designed and managed regulatory system with an independent regulatory agency when economic regulation of prices is based on a contract regulation via PPAs between the IPPs and the incumbent (Stern, 2000). Furthermore, lessons from utilities privatisation in Latin America suggests the need to have a proper regulatory agency in place prior to moving ahead with any contractual arrangements (Gausch et al., 2006).

A single-buyer model such as NEA requires stringent regulatory requirements for its efficient operation and investment as power sector problems can be serious for state-owned single buyer companies operating in countries with imperfect markets and governance with wide-scale corruption (Stern, 2000). There is no explicit regulation on anything else besides the generation prices in the Nepalese electricity sector while there are no regulatory procedures for handling major macroeconomic shocks. The dominant position of the Ministry of Energy with its twin role as owner and decision maker in all spheres of the power sector implies that electricity sector regulation is not independent from vested political interests and thus making the whole regulatory process ineffective in Nepal. As a result, decision making suffers from political influence and instability often lengthening and delaying the decision making process (Krishnan, 2007). An effective regulatory commission as the guardian of public interests should balance and protect the interests and welfare of all stakeholders by creating a level playing field for all stakeholders in undertaking major investment decisions. However, the limited capacity of the regulatory agency and the state remains a challenge in managing and balancing multiple forms of engagement with diverse stakeholders in Nepal (Dubash and Morgan, 2012).

An independent regulatory body requires adequate staff with a range of specialist skills comprising economists, lawyers, accountants, financial analysts and engineers to make regulation effective. This also implies that the institutional continuity of the regulatory system will depend on the regulatory staffs and not on the ruling span of the political party. Hence, there is a need to eliminate the constraints on skilled human resources of new regulatory bodies and agencies with appropriate training of staff to improve incompetence and reduce inefficiency in the regulatory process in developing countries like Nepal. The lessons from Chile and Argentina show that government ministers should not be involved in approving or implementing regulatory decisions while such task should be properly delegated to an independent regulatory agency like CNE for Chile and ENRE for Argentina (Pollitt, 2008a). However, developing economies like Nepal are challenged by inadequate technical capacity, institutional illegitimacy and democratic illegitimacy to make independent regulation feasible (Dubash and Rao, 2008).

Nonetheless, the expansion of the system in the long run necessitates sophisticated regulatory arrangements of the monopolistic transmission and distribution networks in the form of incentive regulation. It is also prudent to have a cautious and planned restructuring of the sector before introducing regulation as effective regulation is a complex and difficult task facing any energy regulator. Inadequate and imperfect restructuring increases the need for intervention and regulation when regulation on its own is incomplete and challenging to pursue in developing countries.

3.6.3. *Restructuring the electricity sector*

NEA is a vertically integrated utility responsible for the generation, transmission and distribution of electricity in the country. Functional unbundling is introduced as a mechanism to facilitate internal unbundling dividing NEA into three main activities: generation; transmission and substation; and distribution and consumer services. While functional unbundling exists on paper, it is necessary to have an accounting separation of the potentially competitive segments and the monopoly segments. Accounting separation can improve transparency and accountability of operation in the sector to attract foreign investors as well as prevent domestic corruption.

Slow and non-transparent decision making process is one of the key areas of concern in the sector (Krishnan, 2007). However, an outright separation of the network in ownership terms in the interim period is not desirable considering the absence of effective regulatory frameworks and small size and density of the market. Delegating decision making authority to the appropriate lowert levels of the government can facilitate timely action by minimising unnecessary bureaucratic delays in a state owned vertically integrated entity like NEA reeling under political instability.

Although the generation segment is open to private investors, barriers to entry still exist in terms of discriminatory network access to the independent power producers. NEA as a single buyer tends to favour its own generation which distorts competition and discourages new entry in generation. Non-integrated private firms are unable to compete for consumers in the market. Eliminating entry barriers in terms of non-discriminatory network access can spur private generation to meet growing electricity demand. Though NEA can remain vertically integrated in the short-run; clear rules for access to networks and appropriate charges should be set in the form of regulated third-party access (rTPA) against negotiated third-party-access (nTPA) to avoid disputes, uncertainty, and corruption (Brunekreeft, 2002; 2004). Further, an independent system operator (ISO) can be created in the long-run to take charge of the dispatch and grid operation under clearly defined rules for access to the grid.

Lessons from Chile suggest that there is a need to separate generation from both transmission and distribution to avoid hold up problems for other generators in large electricity systems (Pollitt, 2004). Argentina learnt lessons from Chile and pursued vertical separation and created a competitive market allowing customers to switch suppliers while no hold-up problems exist in generation (Millan, 2007). Thus, unbundling of NEA remains an option after many years' of being vertically integrated as the system expands over time. This can be done by commercialising NEA's generation, transmission, distribution and support segments followed by privatisation of each of these entities in the presence of an effective regulatory body.

3.6.4. Need to involve the private sector

Nepal has failed to achieve notable progress in development of its hydropower resources than anticipated although domestic and foreign private participation accounts for 26% of the generation market (NEA, 2010). Economic theory suggests that privately owned entities are more efficient than state owned entities due to their profit motives (Baumol, 1996). Private ownership coupled with competition and effective regulation of the transmission and distribution networks can result in cost efficiency, reduced technical and non-technical losses, competitive prices and enhanced revenue collection (Newbery, 2002a). Privatisation of existing assets will also raise revenue for the cash-strapped government with large foreign debts. However, the empirical evidence on the merits of privatisation in the context of electricity reforms are inconclusive (Mota, 2004; Jamasb et al., 2005). In addition, the limited experience of Nepal with the privatisation process suggest that timing of privatisation is crucial to avoid any conflicts between different electricity sector goals as experienced in the electricity reform context of Cameroon (Pineau, 2002).

At present, private participation in the Nepalese power sector is only possible as an independent power producer which gathered pace after the establishment of IPPAN. However, the inability of NEA to strike a favourable PPA with the IPPs due to political resistance to increase end user tariffs in 2011 imply that 1700 MW of hydroelectricity construction projects is being stalled (IPPAN, 2011). Thus, it is necessary that NEA buys power from the private sector at full cost with a fair financial return while raising the end user electricity tariffs to meet the escalating electricity demand in the country. In the short run, private participation through IPPS needs to be bolstered with appropriate incentives for the private sector to participate in electricity generation. Given that both foreign and domestic investors are risk-averse, only a high risk premium can coax the private sector to undertake major investment decisions in the electricity sector operating under political instability. Political instability adds a risk premium to foreign and domestic mode of finance. A high risk premium will also necessitate an increase in the low existing end consumers' tariff across the small systems. Hence, the government should absorb any increase in tariffs through well-targeted subsidies across poor households to prevent social unrest and ensure equity.

Electricity reform lessons from Nicaragua suggest that assessing appropriate risks and designing suitable risk premium forms an integral reform component to lure private sector investments in the energy sector (Mostert, 2007). However, the transition towards larger power systems in the long run can allow the privatisation of the individual segments. The hydroelectricity dominated Norwegian electricity sector reform experience illustrates that privatisation is not a pre-requisite and can wait until the structure, regulation and ownership of the distribution is clear (Jamasb, 2006).

However, the experience of Chile and Argentina suggests that large scale privatisation, if implemented under a robust institutional framework, can be beneficial in terms of enhancing sectoral efficiency. Privatisation in LACs proceeded quite fast and contributed to about 40% of the total value of energy privatisations in the world during the 1990s (Gabriele, 2004). The strong legal protection and observance of private property rights with appropriate regulatory framework as in Chile can deliver benefits in a politically unstable country with small or medium electricity system (Estache et al., 2000). Meanwhile, the Chilean experience also suggests that total privatisations in the electric sector should be carried out according to the country's framework of economic and social development based on market principles and subsidiarity of the state (Morande and Raineri, 1997).

Economic theory also supports that privatisation will result in a lower level of corruption in the sector as the control of the government over the rents offered by the direct operation of public services gets reduced after privatisation (Shapiro and Willing, 1990; Shleifer and Vishny, 1993). The complete or partial transfer of ownership from the government to the private sector in the presence of an independent regulatory body also implies that the bureaucratic influence in power sector decision makings will be minimised with increasing private ownership. This will ensure an unhindered management and operation of the electricity sector irrespective of the changes in political leadership. Hence, a viable option to mitigate the adverse effects of increasing political volatility in the Nepalese power sector would be to completely or partially privatise the sector.

3.6.5. *Sequencing of reform measures*

There seems to be some consensus with regard to the sequence of main reform steps as a part of a good reform design although the sequence of reform steps should be consistent with the needs and specific characteristics of the sector such as resource availability and institutional endowments. According to the generic reform model suggested by Bacon (1999), the key elements of reforms sequence are: i) effective regulation and an independent regulatory body with proper electricity law, ii) restructuring which involves separating and regulating distribution networks followed by the separation and regulation of transmission networks and finally creating a wholesale market by horizontally splitting the segment, and iii) privatising generation, transmission and distribution segments. Most LACs including Chile and Argentina have generally followed the model suggested above although privatisation followed suit before the establishment of the regulator in Brazil.

The Nepalese power sector requires an effective independent regulatory body from the outset while unbundling can be deferred to a later date depending on the future size of the system. The presence of sound regulation can facilitate private participation in by protecting the sector from political volatility and also increasing electricity production to meet demand by employing private capital. The reform experience of the transition economies comprising countries of Southern and Central Europe and the Former Soviet Union also suggest the presence of mass corruption due to ill-guided large scale privatisation in the absence of an effective regulatory body (EBRD, 2001). Consequently, establishing a strong electricity regulatory commission is more urgent than unbundling NEA in the present context.

3.6.6. Critical summary of reform options

These market-based reforms are possible reform options that the Nepalese electricity sector can choose to pursue and thereby are not a strict mandate for reforms. Implementing full reform package based on the standard reform model is currently not desirable in the Nepalese context due to inadequate institutional capacity surrounding the electricity sector. The small size of the sector also does not support the complete adoption of the market-oriented reform package in the short-term. However, certain reforms options are more urgent than others considering the political instability and growing electricity demand facing the sector.

Past power sector reform options and policies failed to produce the desired outcomes in Nepal as these were mostly pursued under external pressures from donor organisations. For example, developing countries were advised to adopt the institutional innovation of regulatory agencies in infrastructure sectors that proved successful in the advanced economies which had adequate institutional endowment. However, many developing countries have been unable to replicate the results observed in developed countries due to insufficient embedding of regulatory agencies within local political and institutional context (Dubash and Morgan, 2012). The Indian state of Orissa provides a distinct example of market-based reform failure in the Indian electricity sector. Orissa achieved all the milestones of the reform program including the privatisation of the thermal power stations and all distribution companies. However, the power sector woes of Orissa did not end while the financial viability of the sector got jeopardised after reforms (Haldia, 2001).

Corruption also remains a major problem in electricity reform in developing countries including Nepal. Thus, privatising the electricity sector as the system gets bigger coupled with creating an independent regulation can partially solve the corruption issues in the Nepalese electricity sector. Estache at al. (2009) empirically documented that privatisation and introduction of independent regulation have partial effects on the consequences of corruption for access, affordability and quality of service in developing countries. Privatisation also reduces the direct involvement of the state in the power sector implying that the sector performance is less affected by political instability. The successful reform experience in Chile and Argentina also suggests the reduced role of the state as market-based reforms were pursued.

However, it is essential for developing countries like Nepal to appreciate that reforms can only be successful if they are implemented properly. In Nepal, a low political commitment to reform coupled with weak implementation of necessary measures due to political instability created a widening gap between theory and practice on the performance of electricity sector reforms. Hence, the reforms must be simple to implement and may not be full-fledged while minimising any potential conflict of objectives among them.

3.7. Conclusions

The purpose of this chapter was to analyse the consequence of more than 20 years of reforms in the relatively small Nepalese power sector. Nepal initiated some reforms in the electricity sector since the early 1990s along with other developing countries. However, the reforms coincided with political instability and civil unrest which affected the reform efforts. Political instability also affected the reform process and outcomes in India, Pakistan, Bangladesh and Sri Lanka. Hence, the reform outcomes suggest minimal performance improvements after reforms implying that the sector remains unsustainable in meeting the growing electricity demand. The analysis suggests that the electricity sector in Nepal is 'resource rich but policy poor'. Hence, reforms may be needed as the vertically integrated sector has failed to deliver as anticipated during the past 28 years.

As such, electricity reforms across small systems like Nepal can be multi-staged. This is because small systems will grow with increasing population and economic growth in the long-run. In the short and medium term, focus needs to be towards tariff and subsidy restructuring and creating an effective independent regulatory body to lead the sector towards recovery and self-sustainability. The importance of establishing an independent regulatory body was largely ignored by policymakers in the Nepalese context. While an independent regulator is necessary to implement the electricity reforms; strong governance and proper institutional arrangements can control corruption, theft and install resistivity toward political shocks in the sector. IPPs entry should also be facilitated and encouraged by minimising unnecessary market and non-market barriers while providing appropriate entrepreneurial incentives. As the system grows in the long run, complete vertical separation of the networks and privatisation of them is an option while creating a wholesale market by horizontally splitting the generation segment. Moreover, accounting separation of the different activities is encouraged in the short term in order to promote transparency and accountability.

It is vital that electricity reforms in small systems like Nepal should primarily be based upon a thorough assessment of economic costs and benefits as an effective way to manage the scarce economic resources properly. It is desirable that need-based reforms relying on individual country's ability and resources receive foremost priority. A cautious and gradual reform process based on a piece-meal approach with constant self-adaptation through error corrections as in the Brazilian context is more suitable for many hydro-rich small systems. Moreover, it is also necessary for developing countries to understand that electricity sector reforms falls within the broader domain of the economic reform and is linked with other sectoral reforms in the economy as a whole.

Lessons from Chile suggest that the role of the state should be limited and be based on the principle of subsidiary prioritising economic logic before vested interests and personal gain. This implies the necessity to redefine and revisit this role in light of market-oriented electricity reforms so as to insulate the sector from political instability and interference. However, the role of state will continue to be crucial and important across small electricity systems like Nepal.

Chapter 4: Reforming the Power Sector in Transition: Do Institutions Matter?

4.1. Introduction

The early 1990s brought about fundamental economic and political changes among the popularly termed ‘transition economies’ (TECs hereafter) comprising twenty-nine countries of Central and Eastern Europe and the Former Soviet Union (FSU). The end of central planning paved the way for economy wide market-oriented reforms in the TECs as a part of pervasive political and economic transformation. The pace and order of these reforms varied markedly across the TECs primarily reflecting the constraints on these governments’ ability and resources. Some countries such as Lithuania, Russia and Slovak Republic opted for instant large scale privatisation without appropriate legal framework as a ‘shock therapy’ which often resulted in significant economic and social costs. Elsewhere, civil wars and ethnic conflicts disrupted and delayed the gradual progress in countries like Macedonia, Bosnia and Herzegovina and Tajikistan. The incentive to join the European Union and benefit from regional integration provided impetus to sectoral reforms in countries across Central and Eastern Europe in the early 2000s. Meanwhile, the isolated Asian economies in the CIS region are still reeling under the legacy of central planning with low political commitment to sectoral reform since independence.

The systemic change of the early 1990’s coincided with the rising popularity of power sector reforms around the world. The power sector was an undisputed choice across the TECs to rapidly undergo marketization in the context of overall macroeconomic reforms for three major reasons: a) the energy-intensive economies were highly subsidised through low power prices prior to collapse, b) the direct and indirect contribution of the power sector towards the country's Gross Domestic Product (GDP) was significant, and c) the sector involved strategic aspects of national energy supply. The inclination towards low resource dependency and energy security coupled with mass politicisation and natural monopoly characteristics of the sector also meant that the role of the power sector was important in determining the speed and magnitude of economic growth for countries experiencing drastic systemic changes. Thus, the role of power sector was seen as being crucial in economic growth policies of the TECs.

After two decades of market-based reforms across the power sectors of TECs; the outcomes can be considered as being mixed, stalled and uncertain (Williams and Ghanadan, 2006). Partly, the present state of the power sector in these countries is a reflection of the fact that the collapse of central planning was not by choice but rather a consequence of non-functioning political and economic system of yesteryear. Belarus and the Caspian countries like Turkmenistan have exhibited great reluctance towards power reforms and have not started the initial process of liberalisation, small scale privatisation and the creation of an environment supportive of private investment. Largely, it also reflects the failure of sure-fire policies of economic advisors to cater to the local conditions in the process of quick transition to a market economy (Stiglitz, 1999). Several new European Union (EU) member states such as Hungary and Bulgaria, though nearing the advanced phase of power sector reforms, still experience chronic power shortages, high distribution losses, lack of investment and vulnerability of energy supply (EBRD, 2007).

Thus, it is debatable whether the reforming countries have significantly benefited from power sector reforms. Likewise, it is worth questioning whether energy-rich countries such as Kazakhstan, Azerbaijan, Russia, Turkmenistan and Uzbekistan have benefited from power sector reforms since 1990 relative to non-energy-rich transition economies even after a gradual real increase in energy prices (Tarr, 1994; Gray, 1995; Pomfret, 2009).

It is tacitly accepted by policymakers that power sector reform in the transition economies has proven to be a difficult and complicated on-going process (Jamasb et al., 2004). The current sectoral performance portrays that formulated policies did not effectively reflect the functioning of a market economy coupled with the misunderstandings of the reform process itself that largely failed to take country-specific conditions into account. However, any concrete econometric studies assessing the performance of electricity reforms in transition economies are missing in the reform literature. This motivates the conduct of an empirical assessment of power sector reforms on the power sector outcomes in the context of overall market-driven economic reforms across the transition countries.

This chapter, therefore, aims to quantitatively assess the less explored link between power sector reforms and wider institutional reforms in the economy across different groups of transition countries. We analyse the link via the impact of reforms on the economic, operational and environmental aspects while accounting for the interactions between power sector reforms and economy-wide institutions. The contributions of this chapter are two-fold. Firstly, the lessons learnt from two decades of reform experiments in TECs can provide valuable indicative insights to the power sector reforms of other developing and less developed countries in Asia and Africa where economic transition is on-going. Secondly, this chapter contributes to the relatively scarce literature on the quantitative analysis of power sector reform across the TECs.

The chapter is organised as follows. Section 4.2 explores the literature encompassing the relationship among different institutional reforms in the economy and power sector reforms. Section 4.3 explains the drivers of power sector reform in TECs. Section 4.4 describes the common economic, technical and environmental aspects across the transition countries at the start of reform. Section 4.5 describes the data and econometric methodology. Section 4.6 discusses the results while Section 4.7 concludes and offers some policy recommendations.

4.2. Review of the Literature

Although economic theory considers both competition and privatisation as the core aspects of a market economy; the outcomes cannot be guaranteed to be Pareto efficient in the absence of proper institutional infrastructure (Rodrik et al., 2004). North (1971) has criticized the standard neoclassical theory as it disregards the role of institutions and time. The New Institutional Economics (NIE) as described by North (1971) and Williamson (1996), considers the importance of institutions and time in the light of market-oriented reforms under two major strands: a) institutional environment (rules of the game which can be explicit, formal or implicit, informal) and b) institutional arrangements which by contrast, are specific guidelines - the so called ‘governance structures’.

However, the early phase of the systemic change in transition economies rested on the false notion that market-oriented policies would automatically install the institutions of a market-based economy during the transition process. This led to a decade of neglecting the institutional differences across countries in implementing power sector reforms while similar approaches to reform led to different outcomes in TECs depending upon the levels of formal and informal institutions in each country (von Hirschhausen and Waelde, 2006). Stiglitz (1999) argued that the enforcement mechanism of reforms were weak as the state's legal and judicial capacities were limited during the transition process brewing inefficient rent seeking and corruption with shock therapy reforms such as large scale privatisation. Hence, the success of market-oriented electricity reforms can tremendously depend on the development of a market-based institutional framework to support the reforms (Hogan, 2001).

Empirical econometric studies by Heybey and Murrell (1997) have concluded that the success of sectoral reforms in transition economies depends much more on the overall institutional framework than on short-term policies. Bacon and Besant-Jones (2001) found evidence of country policy and institutions being positively correlated with reform while country risk being negatively related with reform. Ruffin (2003) using institutional explanatory variables and electricity reform scores found an ambiguous and insignificant relationship between judicial independence and competition. Cornillie and Frankhauser (2004) showed that reform in energy prices and progress in enterprise restructuring are the two most important drivers for more efficient energy use in transition countries. However, a recent study by Nepal (2012b) showed that privatisation has contributed in improving energy efficiency in transition countries even though other market-based economic reforms remain ineffective possibly due to the absence of proper institutions to support market-based reforms.

The role of sector level institutions as key elements to properly understand a market-based economy was overlooked in TECs. Arrow (1972), Hirschmann (1992), Putnam (1993), Fukuyama (1995), Stiglitz (1999) and others have argued that the success of market-oriented economy cannot be understood in terms of narrow economic incentives such as prices but norms, institutions, social capital and trust play critical roles. Pollitt (2009) in relation to the South Eastern Europe (SEE) electricity markets concluded that electricity reform should be a part of wider institutional reforms and successful outcomes cannot be achieved unless there is sufficient economy-wide institutional reform to reinforce power reforms. Kennedy (2003) underscored the importance of a proper institutional context for regulation analysing whether or not a regulator is politically independent for power reforms to produce the desired outcomes based on the study by Levy and Spiller (1996). However, the criteria vary when assessing whether a regulator can be considered independent or not. The widely used criteria are the nature and terms of regulatory appointment, source of funding of the regulatory body and the extent of participation of the regulators in designing regulatory content such as tariff methodology (Stern 1997; 1998).

Following Easterly and Levine (2003), two relevant views on the relationship between overall institutional development and power sector reforms are reflected in this chapter. The first view holds that electricity sector reform performs through long-lasting institutions in the absence of which policy becomes ineffective. Economies where reforms are most effectively implemented do so by adapting to the required political and legal changes through suitable institutional development. This implies that the role of technology is endogenous to the institutions as reforms implemented determine the necessary arrangement for adoption of better technology. The second view maintains that institutional reforms should be context specific in terms of know-how and political conditions to produce any significant impacts.

4.3. The Motivation for Power Sector Reform in TECs

Though reform was much needed and indeed inevitable in the power sector of TECs; factors external to the sector played a major role to catalyse the reform process. For example, Hungary pursued power reform in order to reduce the fiscal deficit through large scale privatisation while for the Czech Republic and Russia; reforming the power sector was part of an overall ownership change. The most important factor was the limited public resources to continue financing the sector with short-run excess capacity (Williams and Ghanadan, 2006; Bacon and Besant Jones, 2001, Joskow 1998). While economic efficiency, competition and choice were the main drivers of electricity reform in the developed economies such as OECD; these aspects were secondary in electricity reform in the TECs. The oil shocks of the 1970s led to soaring foreign debt, budget deficits and high inflation forcing the governments in the TECs to implement economic adjustment programs to mitigate the macroeconomic and fiscal crisis. The power sector and other state-led utilities were favoured candidates to undergo restructuring as these sectors had the greatest potential for deficit reduction and revenue generation through corporatisation and privatisation. Hence, power reforms for cost recovery and private investment followed suit as an alternative source to finance the sector and raise government revenue (Jhirad, 1990).

International development institutions such as the World Bank, the Asian Development Bank (ADB), the European Bank for Reconstruction and Development (EBRD), and the Inter-American Development Bank (IADB) also played a role in initiating power sector reforms as the economic stabilisation loans came with conditions attached to reform the power sector in the TECs (Bacon and Besant-Jones, 2001). Furthermore, as of early 2000 the prospect of EU accession had a significant influence on the extent of power reforms in many Central Eastern Europe and Baltic States (CEB) and South Eastern Europe (SEE) as these countries needed to meet the minimum standards of the EU to gain a membership (EBRD, 2001). Following Jamasb et al. (2005), the motives behind power sector reforms in the TECs are summarised in Table 4.1 in terms of 'push' and 'pull' factors. While 'push' factors include the unfavourable macroeconomic conditions; 'pull' factors captures the incentives and obligations associated with power sector reforms.

Push Factors	Pull Factors
1) Macroeconomic events: 1970 oil crisis, Post-Soviet economy-wide market-based transition (1989), Asian Financial crisis (1997-1998), economy-wide liberalisation and reform programs as initiated by the fiscal crisis *2) Limited national fiscal ability*: high public debt, utility borrowing as a major proportion of national debt *3) Investments constraints of the power sector*: no ability to self-finance, system upgrading and modernization required, high projected electricity demand	*1) Capital raising options*: privatisation of state assets, greenfield private investment *2) Lending for institutional reform*: macroeconomic stabilization lending conditional upon power sector restructuring, asset privatisation (IMF), liberalisation and reform for new power sector loans (World Bank in 1993) *3) Spill-over effects from international experiences* : learning from pioneering reforms of power sectors in Chile, England and Wales and Norway in the 1980s and early 1990s *4) EU accession*: opportunities to benefit from regional integration by reforming the power sector in accordance with the EU Directives 5) *OECD Deregulation*: new energy multinationals created as a result of OECD energy sector deregulation, provided investment opportunities for Europe and USA

Table 4.1: Drivers of power sector reforms in TECs

The early phase of reform policies were predominantly based on the theoretical analysis and policy recommendations of economic advisors influenced by electricity sector deregulation experiences in Europe and USA. A standard menu of reform for the TECs and non-OECD countries was prescribed by the World Bank through the reform ‘scorecard’ (World Bank, 1999). The major elements of the menu followed a gradual progression from forming energy laws to sector corporatisation and commercialisation with an independent energy regulator in place that eventually led to sector restructuring and privatisation (Jamasb, 2006). The creation of competitive wholesale markets was the last step to fully complete the reform process. While establishing a spot market or pool was one of the most innovative reforms of privatisation in the power sector of the TECs; whether it led to cost-reflective bidding remains inconclusive (Newbery, 1994).

However, the ‘scorecard’ as well as the earlier power sector reform programme is criticized on the grounds that the local contexts were thoroughly ignored (Bacon and Besant-Jones, 2001). The advisors from the World Bank, International Monetary Fund (IMF), EBRD and United States Agency for International Development (USAID), who initially came over to help these countries did not understand the extent to which institutions mattered in electricity reforms. The experience followed by a standard menu of reform based on OECD models as part of the structural adjustment programmes has proved unsuccessful as electricity reform in developing countries is different from OECD reform in terms of reform drivers, initial context and institutional aspects (Nepal and Jamasb, 2013). On the other hand, the lack of reform experience among developing countries meant that electricity reforms in Norway and the UK served as starting points while policy formulation was also based on trial and error as in the Indian context (Sen and Jamasb, 2012). Chile was the only non-OECD country that implemented a relatively successful electricity reform process already in the early 1980s. The focus of the standard menu of reforms was primarily financial with societal concerns such as access, service quality, socially efficient pricing and environment being ignored (Williams and Ghanadan, 2006). Further, policymakers ignored that electricity reform in the TECs is not an undertaking that is confined to the sector but one that is closely interlinked with broader legal and institutional contexts throughout the economy.

Hence, this chapter takes a quantitative approach in exploring the high-level links between power sector reforms and other institutional reforms in the economy. We expect that effective power sector reforms should engender significant impacts on the economic, technical and environmental aspects of power sector across the TECs during 20 years of reforms experience.

4.4. Initial Context of Reforms

The power sectors of transition economies in the Former Soviet Union and Central and Eastern Europe had some common economic, technical and environmental features at the beginning of the reform period. The initial economic, technical and environmental context of reforms is discussed below:

4.4.1. Declining GDP

The transition countries experienced falling GDP in the aftermath of the oil crisis of 1979 and 1980s. The contractions in real GDP during the early reform phase in Central Europe were comparable to the 20% fall in the US during the Great Depression while for other CEB and Commonwealth of Independent States (CIS) economies such as Russia and FSU the fall was even higher (Stern and Davis, 1997). Hence, boosting national GDP was one of the objectives of the economic reforms in TECs. Reforming the power sector was considered appropriate by the transition countries as a major way to recover from the fiscal crisis. The fall in GDP coincided with major fall in energy consumption significantly lowering industrial output and vice-versa.

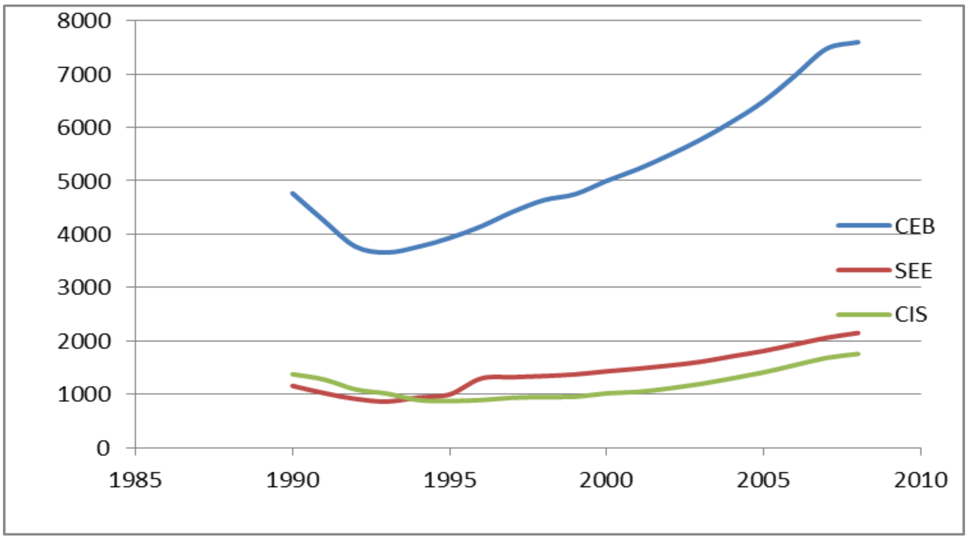

Figure 4.1: Per capita GDP from 1990-2008 **(in constant 2000 US dollars)**

Figure 4.1 above traces the per capita GDP of the CEB, SEE and CIS countries from 1990-2008. All country groups experienced a recovery after the Asian financial crisis although the CEB region experienced the greatest decline. The reason could be that the CEB region includes 7 out of 9 countries in the EU with a strong industrial base and got affected by declining energy consumption. All countries experienced a significant fall in per capita GDP during the early phase of transition.

4.4.2. *Excess capacity*

Although the region had ample capacity; the breakup of the Soviet Union also broke the integrated energy supply system allowing the oil and gas prices to rise as par to the international levels. The hike in energy prices produced an energy price shock in the oil importing countries. Energy supply from other FSU producers such as Kazakhstan and Turkmenistan also experienced frequent disruptions with the Russian monopoly over export routes through Ukraine, Slovakia, and the Czech Republic. As of 1989, numerous nuclear reactors in Armenia, Bulgaria, Lithuania, Russia, Slovakia and Ukraine had an installed capacity of 300 gigawatts (Gray, 1995). Several unsafe nuclear plants were shut down such as the closure of, Chernobyl in Ukraine in 2001. With demand for electricity rising in particular and supply security being increasingly threatened, the early experience of excess capacity has come to an end (EBRD, 2008). Figure 4.2 shows that the gross generating installed capacity in the CIS region was increasing after 2000 while the figures are fairly stable in the SEE region since 1991.

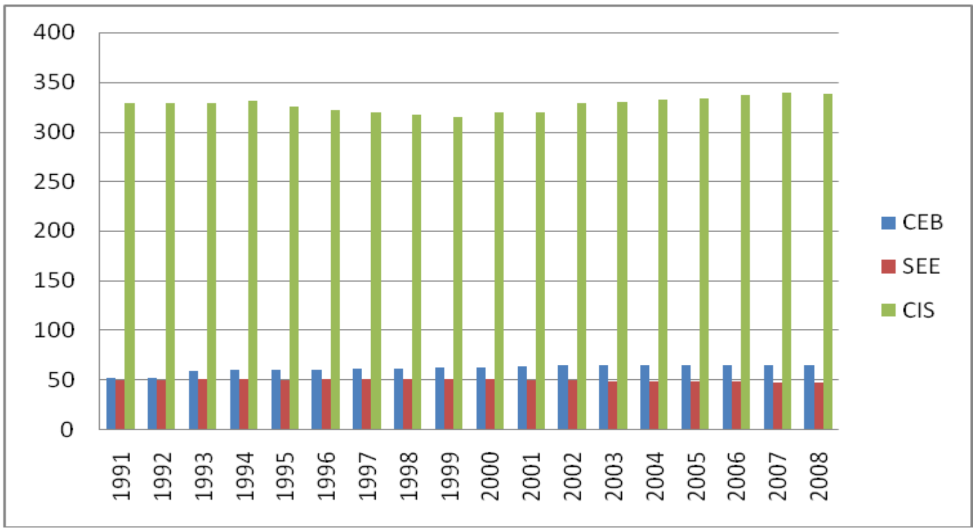

Figure 4.2: Capacity mix in 2007 across TECs **(in million kilowatts)**

Increasing environmental obligations such as EU renewable energy targets have prompted the transition countries associated with the EU to expand their renewable energy base. The phasing out of unsafe nuclear plants and the motives to reduce emissions from dirty coal has induced investment in renewable generation capacity in the transition regions. The transition towards a less carbon intensive economy combined with the need to meet the increasing electricity demand has prompted countries to invest in renewable capacity expansion among the transition countries.

The importance of the power sector to the economy and excess capacity was reflected in higher electricity production before reform started after which electricity production declined due to the economic slowdown. The fall in national GDP across the TECs after reform led to lower electricity demand and also lowered the electricity production. The Asian financial crisis seems to have negatively affected the CIS region the most in terms of power production. A decisive factor is the declining industrial demand for electricity among the energy-intensive industries during this period (Stern and Davis, 1997). Figure 4.3 shows that the power production declined for the CIS region during the early phase of transition process increased after 2000. However, the SEE region has the largest renewable electricity production though thermal production dominates all regions. The CEB region produced the least amount of electricity from nuclear sources consisting only 9% in 2007 (EIA, 2010).

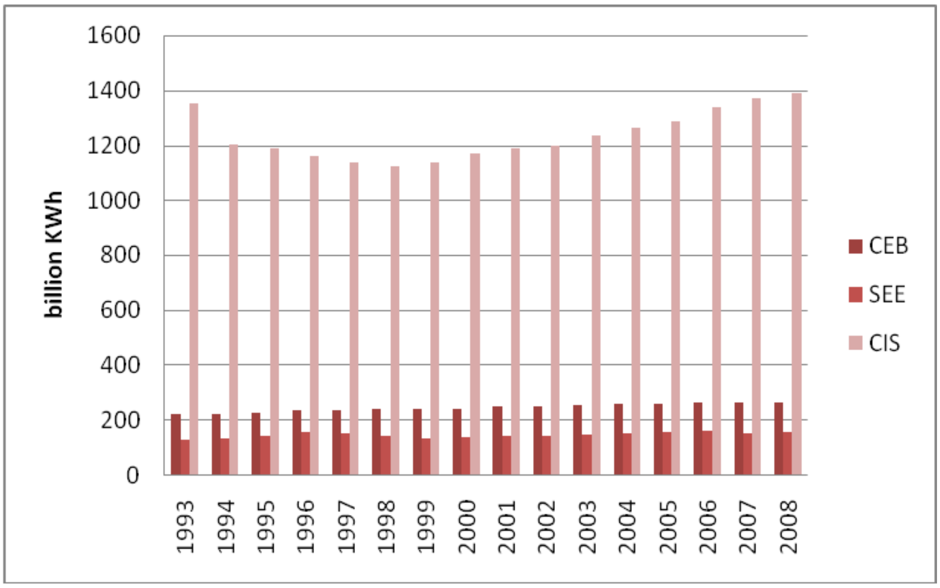

Figure 4.3: Electricity production across TECs from 1993-2008

4.4.3. *Low and distorted electricity prices*

Most prices in the centrally planned economies were set administratively, with little regard for cost and demand considerations (IMF, 1997). Prices were on the whole subject to strict controls while measured inflation was most of the time low and repressed. The energy prices in the transition economies were also de-aligned from economic cost with tax revenue being used to subsidise consumer groups such as households. The price structure was distorted and based on cross-subsidisation as low household prices were achieved by charging relatively higher prices for industrial users. However, the practice of lower prices of electricity to households seems to have been maintained during the transition period as illustrated by Table 4.2 especially in the CIS countries with twin problems of low bill collection and high commercial losses. The low power prices have been a major obstacle in terms of financially supporting the system.

Countries	Residential price (USc/kwh)	Industrial price (USc/kwh)	Bill collection (%)	Commercial losses (%)
Albania	2.9	7.2	84.5	11.2
Armenia	4.4	2.9	87	30
Estonia	4.9	4.1	97.1	1.1
Hungary	6.8	5.7	90	na
Romania	5.2	4.8	62	2
Bulgaria	3.7	3.9	85	10
BIH	5.6	6.1	95	11.5
Georgia	4.2	3.3	32	27.5
Tajikistan	0.2	1.1	na	14
Uzbekistan	0.7	0.7	25	na
Turkmenistan	0.5	0.5	30	na

Table 4.2: Prices, cash collections and commercial losses in selected TECs

Source: Adapted from Kennedy (2001)

The lack of adequate revenue generation from electricity sales is also reflected by the high electricity losses among the transition countries. The losses remain the lowest on average in the CEB region and the highest in the SEE region (EIA, 2010). For example, Albania belonging to the SEE region had the losses reaching 69% of output produced in 2006. The high level of losses could indicate the poor state of the transmission and distribution networks in need of maintenance and upgrading. On the other hand, the high technical losses also demonstrate the lack of investment in the network infrastructures to upgrade and maintain them.

4.4.4. High energy intensity

The energy consumed per unit of GDP in the transition economies was historically estimated at four to eight times to that of OECD countries and the United States (Gray, 1995). The high energy intensity of the past can be attributed to the presence of many energy intensive industries and the inefficiency of energy use spurred by lower power prices. Furthermore, the distorted energy prices and soft budget constraints for industry also led to high energy use in the TECs. The CIS countries being the most energy intensive have reduced their energy intensity by about one-third since 1994 (EBRD, 2008). However, these countries still use three times more energy as compared to Western Europe to produce a unit of GDP in terms of purchasing power parities (PPP). Uzbekistan, Kazakhstan and Turkmenistan are highly energy intensive among the CIS countries. Hence, there is a significant potential in the TECs to be more energy efficient and converge at similar levels with the OECD countries in terms of per capita consumption of electricity (Markandya et al., 2006).

4.4.5. High carbon emissions intensity

Many CEE and FSU countries relied heavily on low-quality and high polluting coal and lignite in the past. While reliance on coal and lignite was an alternative to not being dependent on Russian oil and gas; it also meant high levels of carbon and sulphur emissions. For example, coal comprised 90% of all fuel used for power generation in Poland and 60% in the former Slovakian Republic in 1995 (Gray, 1995). The transition countries met 6% of its total energy consumption from renewable sources in 1999 (EIA, 2010). While the CEB and SEE countries consumed 7.5 million tonnes of oil equivalent (mtoe) of renewable energy; the amount was 57.5 mtoe for CIS countries.

Of the world's 20 most carbon intensive economies, 13 countries belong to the TECs (CDIAC, 2005). Kazakhstan and Russia are among the top 15 carbon polluters. Among the countries included in the United Nations Framework Convention on Climate Change (UNFCC), Kazakhstan, Bosnia and Herzegovina and Armenia are listed as the three most carbon intensive economies.

However, the impact of power sector reforms in the context of overall macroeconomic reforms remain to be examined in relation to these economic, technical and environmental aspects after more than two decades of reforms. This chapter attempts to do so.

4.5. Data and Econometric Methodology

The aim of this chapter is to investigate the link between power sector reforms and wider institutional reforms in the economy since the start of the transition process across 27 TECs. This chapter uses the 'Transition Indicators' developed by the EBRD which measures the overall progress in transition countries through a set of indicators. The transition indicator scores reflect the judgment of the EBRD's Office of the Chief Economist about country-specific progress in transition (EBRD, 2001). The reform scores reflect the assessments of EBRD country economists. The measurement scale for these indicators ranges from 1 to 4+, where 1 represents little or no change from a rigid centrally planned economy while 4+ represents the standards of an industrialised market economy. This chapter uses the transition indicator scores as a proxy to measure the role of institutions in the transition countries. Table 4.3 explains that a score of 4+ in power sector reforms imply that electricity tariffs are fully cost-reflective and provide adequate incentives for efficiency improvements, the presence of large-scale private sector involvement in the unbundled and well-regulated sector and fully liberalised sector with well-functioning arrangements for network access and full competition in generation (EBRD, 2001; EBRD, 2008). It also shows that the each reform steps builds upon the preceding reforms.

The following five institutional indicators from the available set of nine EBRD indicators are constructed:

- *Economic Governance Reform Index **(EGRI)***: composite index based on un-weighted average of large scale privatisation and corporate governance and enterprise restructuring indices.
- *Overall Market Liberalisation Index **(OMLI)***: composite index based on un-weighted average of price liberalisation, competition policy, and trade and foreign exchange indices.
- *Other Infrastructure Reform Index **(OIRI)***: composite index based on un-weighted average of reform scores in roads, water and waste water and telecommunication indices.
- *Financial Sector Reform Index **(FRI)***: composite index based on un-weighted average of banking reform and interest rate liberalisation and securities markets and non-bank financial institutions indices.

➢ *Power Sector Reform Index* ***(PRI)***

1	Power sector operates as government department, few commercial freedoms or pressures, average prices well below costs, extensive cross-subsidies, and monolithic structure and with no separation of different parts of the business.
2	Power company distanced from government but political interference exists, attempts to harden budget constraints but effective tariffs are low, weak management incentives for efficient performance, little institutional reform and minimal private sector involvement (if any).
3	Law passed providing for full-scale restructuring of industry, including vertical unbundling through account separation and set-up of regulator, some tariff reform and improvements in revenue collection and some private sector involvement.
4	Separation of generation, transmission and distribution, independent regulator set up, rules for cost-reflective tariff-setting formulated and implemented, substantial private sector involvement in distribution and/or generation and some degree of liberalisation.
4+	Tariffs cost-reflective and provide adequate incentives for efficiency improvements, large-scale private sector involvement in the unbundled and well-regulated sector, fully liberalized sector with well-functioning arrangements for network access and full competition in generation.

Table 4.3.: Components of power sector reform index

Source: Adapted from EBRD (2001)

Further, in order to analyse the relationship between the institutional frameworks on macroeconomic and power sector outcomes (economic, operational and environmental), the following three performance indicators were used as described below:

- *Economic impacts*: includes per capita GDP (PGDP) and per capita installed capacity or the available supply capacity ***(PINSTC)***
- *Operational impacts*: includes operational aspects namely per capita transmission and distribution losses ***(PTDL)*** and per capita electricity production ***(PEPDN)***
- *Environmental impacts:* carbon emissions intensity ***(CEI)*** and per capita renewable installed *capacity* ***(PRINSTC)***

However, both household and industrial electricity prices are not included in the analysis due to the lack of reliable and comprehensive data for all transition economies. Table 4.4 shows the status of the countries included in the sample. The transition countries studied in our sample can be divided into three distinct groups namely CEB, SEE and CIS based on European Bank of Reconstruction and Development (EBRD) classification. 15 out of the 27 countries included in our sample are associated with the EU. Some transition countries included in our sample have already obtained a membership at the EU while some are in the process of being an EU member and have the potential for joining EU. Turkey and Montenegro are excluded from our sample due to data unavailability on the predictor and criterion variables respectively. In addition, Montenegro became an independent state from 3 June 2006.

Central Eastern Europe and Baltic States (CEB)	South Eastern Europe (SEE)	Commonwealth of Independent States (CIS)	Others
Croatia**, Estonia*, Hungary*, Latvia*, Lithuania, Poland*, Slovak Republic* and Slovenia*	Albania***, Bosnia and Herzegovina***, Bulgaria*, FYR Macedonia** , Serbia, Romania* and Montenegro***	Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan	Turkey** and Mongolia
EU members, ** EU candidates and * Potential EU candidates*			

Table 4.4: Countries included in the study

Source: Adapted from EBRD (2001)

The dataset, thus, is an unbalanced panel comprising 27 cross-sections (N) with short time series (T) of 19 years observed from period 1990-2008. The year 1990 was the start of the transition process among the TECs. The cross-sections represent different countries with their own economic, political and cultural system and history allowing the possibility for individual country-specific characteristics to influence the behaviour of each country. It is likely that unobserved heterogeneity such as culture, legal origin, geographical location and historical origin which are fixed over time is likely to be correlated with the wider economic reforms. Hence, panel data econometrics based on fixed effects (FE) is used to account for unobserved heterogeneity. Table 4.5 summarizes and lists the dependent and independent variables used in the models.

However, the relationship between the institutional framework and power sector outcomes is a complex one as the creation of a suitable institutional environment does not instantaneously lead to improved outcomes. The behaviour of dependent variables can depend upon the past values of itself along with a set of independent and control variables (Bruno, 2005). Thus a dynamic specification of the panel model can be specified as $y_{it} = \Omega y_{it-1} + X_{it}\beta + \alpha_i + u_{it}$ where 'Ω'is the coefficient of the lagged value of the dependent variable while '$X_{it}\beta$' represents the matrix of explanatory variables and coefficients. Hence, a dynamic FE model is applied in this study.

Type	Variables	Description	Units	Source
Independent Variables	PRI	power reform index	scaled from 1 to 4+	EBRD
	OIRI	other infrastructure reform index	scaled from 1 to 4+	EBRD
	FRI	financial reform index	scaled from 1 to 4+	EBRD
	EGRI	economic governance reform index	scaled from 1 to 4+	EBRD
	OMLI	overall market liberalisation index	scaled from 1 to 4+	EBRD
Control variable	LNPECS	per capita electricity consumption	kilowatt hour (KWh)	CIA World Factbook
Conversion variable	POPULATION	includes all residents regardless of legal status or citizenship	total number	WDI
Dependent variables	LNPGDP	per capita GDP or per capita income	constant 2000 US dollars	WDI)
	CEI	carbon emissions intensity	metric tons of CO_2 per thousand year	EIA
	LNPINSTC	per capita installed capacity	KWh per person	EIA
	LNPRINSTC	per capita renewable installed capacity	KW per person	EIA
	LNPEPDN	per capita electricity production	KWh per person	EIA
	LNPTDLS	per capita transmission and distribution losses	KWh	WDI

Table 4.5: List and description of variables

It is well established in the econometric literature that a dynamic least square dummy variables (LSDV) model with a lagged dependent variable engenders biased estimates when ‘T’ is small (Roodman, 2006). Thus, an alternative to dynamic LSDV panel estimates would be to use other consistent Instrumental Variable (IV) such as Anderson-Hsiao (AH) and Generalized Methods of Moments (GMM) estimators such as Arellano-Bond (AB) and Blundell-Bond estimators (BB). The AH estimator precludes the fixed effects by transforming the data into first differences and uses the second lags of the dependent variable (either differenced or in levels) as an instrument for the one-time differenced lagged dependent variable (Anderson and Hsiao, 1981). The AB estimator is a GMM estimator for the first differenced model relying on a greater number of internal instruments (Arellano and Bond, 1991). The BB estimator assumes that the first differences of the instrumental variables are uncorrelated with fixed effects and augments the AB estimator by allowing for more instruments and improving efficiency (Blundell and Bond, 1998).

However, the relative performance evaluation of bias-corrected LSDV estimate (LSDVC) by Bruno (2005) in comparison to LSDV, AH, AB and BB estimator for unbalanced panels with small 'N' concludes that the STATA computed LSDVC version outperforms all other estimators in terms of root mean square error (RMSE) and bias. Thus, the LSDVC model by Bruno (2005) for unbalanced panels is used to examine the dynamic relationship for all estimators used to initialize the bias corrections (AH, AB and BB). The LSDVC estimator can be applied under two fundamental assumptions: a) it has a strictly exogenous selection rule and b) the error term 'u_{it}' is classified as 'an unobserved white noise disturbance'. The use of indexes based on individual components score as regressors and considering electricity demand as given largely confirms to the exogenous selection rule. The standard test statistics along with the Arellano-Bond test for first and second order autocorrelation is reported. Under the null of no autocorrelation, the presence of second order autocorrelation would imply that the estimates are inconsistent. In addition, the estimates of the Sargan test of overidentifying restrictions reported by the Blundell Bond estimator should test significantly different from zero to reject the null that overidentifying restrictions are valid. Using 'xtlsdvc'command in STATA, the estimator first produces uncorrected LSDV estimates which then approximates the sample bias of the estimator using Kiviet's higher order asymptotic expansion techniques (Bruno, 2005; Kiviet, 1995).

All dependent and independent variables except indexes have been logarithmic transformed. Following Sen and Jamasb (2012) and Zhang et al. (2008); the first model (Model I) to be estimated in examining the relationship between reforms and outcomes is:

$$\boldsymbol{Y_{it} = \Omega Y_{it-1} + PRI_{it}\beta_1 + OIRI_{it}\beta_2 + EGRI_{it}\beta_3 + FRI_{it}\beta_4 + OMLI_{it}\beta_5 + LNPECS_{it}\beta_6 + \alpha_i + u_{it}} \tag{1}$$

However, the motives to reform the power sector in the TECs were primarily external. Hence, reforms in external sector upon interaction with the power sector could have affected the macroeconomic and power sector outcomes. This study accounts for the interaction among the reform variables by constructing the interaction terms. The interaction terms have been derived by multiplying the indexes under consideration. Thus, model II introduces an interaction term between the power sector reforms with wider economic institutional reforms as specified below:

$$\boldsymbol{Y_{it} = \Omega Y_{it-1} + PRI_{it}\beta_1 + OIRI_{it}\beta_2 + EGRI_{it}\beta_3 + FRI_{it}\beta_4 + OMLI_{it}\beta_5 + LNPECS_{it}\beta_6 + OIRI_{it}{*}PRI_{it}\beta_7 + EGRI_{it}{*}PRI_{it}\beta_8 + PRI_{it}{*}FRI_{it}\beta_9 + PRI_{it}{*}OMLI_{it}\beta_{10} + \alpha_i + u_{it}} \qquad (2)$$

Both models use per capita electricity consumption as a control variable. Table 4.6 below reports the descriptive statistics of variables used in our study. It can be inferred that liberalising the economy as a whole (opening up trade, establishing proper competition policies and price liberalisation in the economy) has been high on the reform agenda across all transition countries. However, overall price liberalisation in the economy has not been necessarily applied to the power sector as all groups of countries considered are still a distance away from achieving cost-reflective pricing of electricity. Thus, the power sectors in the TECs have been reformed the least in relation to the standards of an industrialised market economy. However, disaggregating the diverse set of countries into different groups based on their common characteristics would allow studying the relative institutional reform progress more precisely than solely relying on the overall average.

Variable	Mean	Standard Deviation	Minimum	Maximum	No. of Observations
LNPRINSTC	-2.211	2.061	-8.526	0	490
LNPREPDN	5.407	2.315	-5.195	8.013	472
LNPGDP	7.360	0.992	4.805	9.532	509
LNPINSTC	-0.141	0.474	-2.282	0.809	490
LNPEPDN	-5.801	0.513	-7.108	-4.502	513
LNPTDLS	-7.782	0.431	-8.977	-6.663	513
PRI	1.994	0.814	1	3.67	513
OIRI	2.013	0.796	1	3.92	513
EGRI	2.236	0.855	1	3.84	513
OMLI	2.949	0.888	1	4.22	513
FRI	2.065	0.810	1	4	513
LNPECS	7.866	0.515	5.979	8.873	513

Table 4.6: Descriptive statistics for the variables

Figure 4.4 confirms that economic liberalisation was highly pursued across the transition countries. The figure also depicts some degree of institutional convergence among PRI, OIRI, EGRI and FRI variables across all CEB, SEE and CIS member states. The CEB countries which include 7 out of 9 EU members seem to have experienced a stagnation of institutional reforms including power sector reforms though the financial sector reforms is following an upward trend. However, the SEE countries exhibit an upward reform trend in other institutional reforms except for the power sector. On the other hand, the CIS countries show a mixed picture. The steep upward trend in PRI among CIS countries reveals that these countries have some catching up to do in relation to their counterparts in reforming their power sectors. The overall market liberalisation process seems to have flattened out after 2004 while reforms in economic governance, other infrastructures and financial sector are gaining pace.

A detailed analysis of EU members gives a clearer outlook on the progress of power sector reforms. Electricity reforms seem to have sped up after financial crisis till EU accession in 2004 (Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia) before a brief moment of respite. The reform process again gained pace until 2005 with Bulgaria and Romania in the process of joining EU. However, power sector reform appears to have stagnated among the EU members after 2005 while other institutional reforms show a slow upward trend. Likewise, the power sector reform gained pace in the potential EU candidates (Albania, BIH, Montenegro, Serbia, Croatia, FYR Macedonia) after 2000 but with stagnation post 2005. Other institutional reforms in the EU candidate countries show an upward trend. Hence the motivation for joining EU indeed has acted as incentives to accelerate power sector reforms across these countries.

A further analysis of the oil and gas rich transition countries such as Azerbaijan, Kazakhstan, Russia and Turkmenistan shows that power sector reform gained pace after 2000 with a reversal around 2004 and stagnation after 2005. While reforms in other infrastructures are speeding up, reforms in overall market liberalisation, economic governance and financial sector reform have stalled.

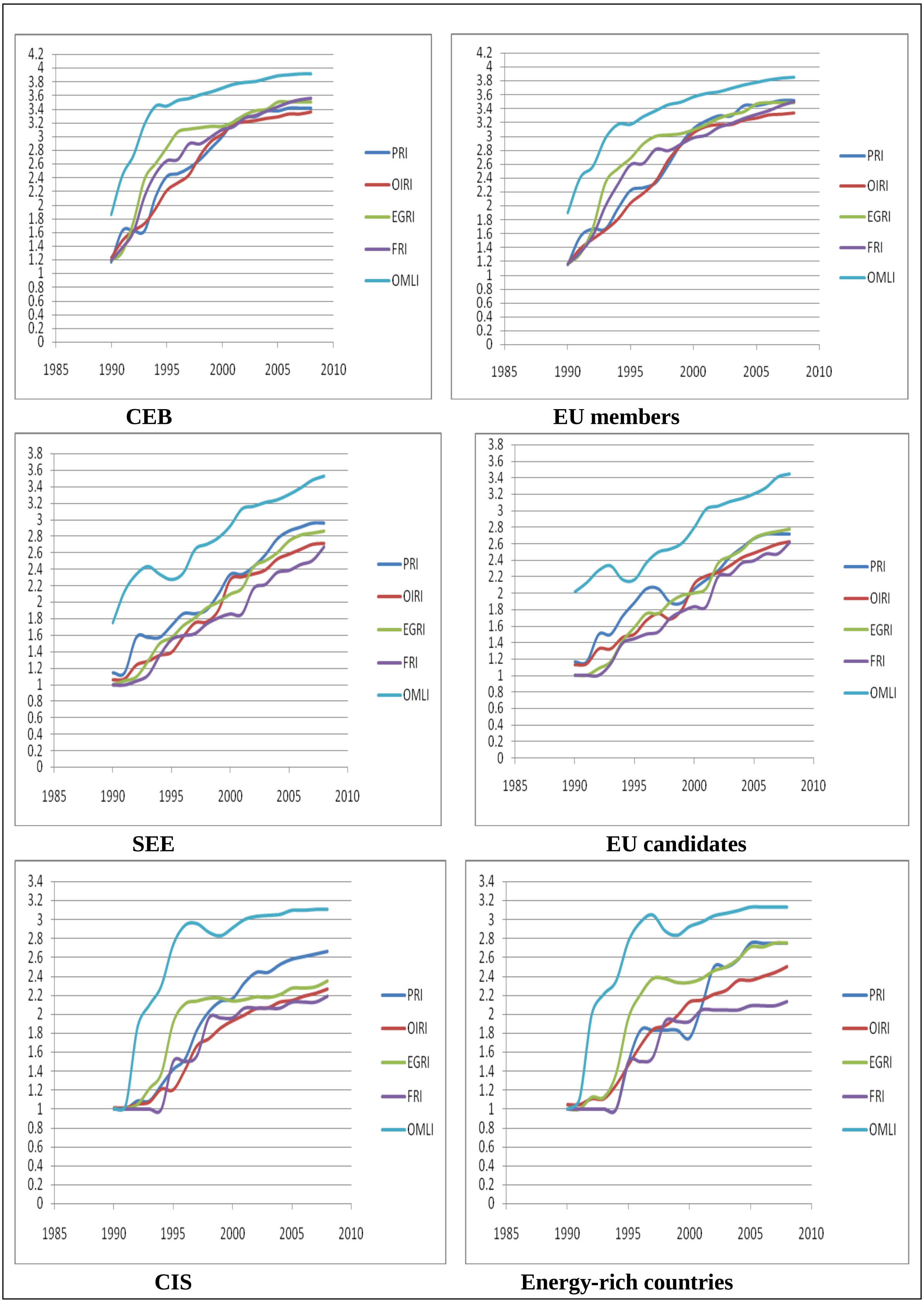

Figure 4.4: Graphical analysis of economy-wide reform progress

Note: The vertical axis represents the EBRD transition scores ranging from 1 to 4+.

4.6. Results and Discussions

This section presents and discusses the results based on Model I and Model II estimated using the 'LSDVC' technique. The findings are organised under the economic, operational and environmental impacts of reforms. Model I explains the 'on its own' impact of reforms over-time. Model II explains the outcomes of reforms accounting for interrelations between the power sector reforms and other institutional reforms. The bootstrapped standard errors are reported in brackets. A third order bias correction was performed while the number of bootstrapping repetitions was confined to 50 depending on the number of observations. For all econometric estimations, the AB tests of autocorrelation and BB test of over identifying restrictions were performed to assess the model choice though the results are not reported in this chapter. OLS and FE estimations were carried out and the results were compared to determine the nature of bias for each hypothesis. In all cases, bias estimates were observed as OLS and FE do not take endogeneity among regressors into account.

4.6.1 *The economic impacts of reform*

Per capita GDP and per capita installed capacity were used as outcome variables in order to assess the economic impacts of inter-sector reforms in the TECs. Changes in per capita GDP imply changes in economic growth while per capita installed capacity or available supply capacity is a proxy for power sector endowment and indicates the size of the system. An increase in the per capita installed capacity is particularly associated with new capital being attracted to the power sector due to factors such as privatisation and Greenfield projects.

i) Impacts of reforms on per capita GDP: The results in Table 4.7 show that the lagged value of GDP is significant implying that last year's GDP had an effect on previous years' GDP across the transition countries. Power sector reform *on its own,* does not bring about a change in per capita GDP. However, the power reforms appear to significantly affect the GDP when accounting for interactions between power reforms and other institutional reforms. Interestingly, electricity reforms when considered along with overall market liberalisation reforms had a significant negative effect on per capita GDP. This could be explained on the grounds that while competition is an essential part of market-based electricity reforms, competition policy in the economy as whole in

TECs has progressed above those required by the power sector. The average progress in reforms for 'OMLI' and 'PRI' is table 4.6 also supports this view. This renders great responsibilities on competition authorities to implement reforms in the power sector as inter-sector competition reforms are not synchronized (Pollitt, 2009). In contrast, some transition countries have introduced full unbundling in the power sector while the competition policy in the economy as a whole remains ineffective in these countries producing counter-conducive results to power sector reforms.

Variables	Anderson-Hsiao		Arellano-Bond		Blundell-Bond	
	Model I	Model II	Model I	Model II	Model I	Model II
L.LNPGDP	0.896*** (0.038)	0.893*** (0.002)	.935*** (0.030)	0.967*** (0.041)	0.975*** (0.043)	0.942*** (0.031)
PRI	0.003 (0.005)	0.125*** (0.021)	0.005 (0.004)	0.060*** (0.020)	0.003 (0.008)	0.099*** (0.027)
OIRI	0.030*** (0.007)	0.049** (0.021)	0.009 (0.007)	0.044** (0.018)	0.006 (0.010)	0.057* (0.031)
EGRI	0.068*** (0.007)	0.051* (0.027)	0.012* (0.006)	0.009 (0.023)	0.016* (0.008)	0.019 (0.031)
OMLI	0.063*** (0.007)	0.015 (0.019)	.015** (0.006)	0.016 (0.017)	0.016 (0.008)	0.024 (0.021)
FRI	0.009 (0.298)	0.020 (0.031)	0.007 (0.274)	0.019 (0.027)	0.005 (0.010)	0.016 (0.031)
LNPECS	0.171*** (0.011)	0.073*** (0.011)	0.004 (0.011)	0.006 (0.012)	0.035** (0.004)	0.042** (0.025)
*PRI*OIRI*		-0.025 (0.010)		-0.015 (0.009)		-0.022 (0.015)
*PRI*EGRI*		-0.002 (0.013)		0.001 (0.011)		-0.006 (0.015)
*PRI*OMLI*		-.051*** (0.117)		-0.008 (0.011)		-0.017 (0.017)
*PRI*FRI*		-0.008 (0.015)		-0.001 (0.013)		-0.042 (0.124)

Table 4.7: Impact of reforms on per capita GDP

*, **, *** denotes significance at 10, 5 and 1% respectively

Reforms in other infrastructures (telecommunication, water and roads), economic governance (large scale privatisation and enterprise restructuring), and overall market liberalisation (opening up trade, liberalising prices under certain competition policy) all produced a significant impact on per capita GDP. Thus, we can infer that regional integration and increasing cross-border trading of goods and services (including the energy trade) boosted national GDP. However, it is not clear which particular aspects of institutional reforms were important in influencing the GDP and which countries gained or lost. Nonetheless, countries that had the macroeconomic motives to reform their power sector benefited when power sector reforms took place in conjunction with institutional reforms as suggested by the results.

Per capita electricity consumption also has a significant effect on per capita GDP in the transition countries confirming that these countries are energy-intensive. The traces of decade's long experience of the economy based on cheap and state subsidised energy in the transition countries seems to be still present as confirmed by the overall results.

ii) ***Impacts of reforms on per capita installed capacity*:** Per capita installed generation capacity remained fairly inelastic to power sector reforms and per capita electricity consumption in the transition countries as observed in Table 4.8. The one-lagged coefficient is significant indicating that last year's capacity is an important indicator for the current year's capacity. All other institutional coefficients except for EGRI (with and without interaction terms) are insignificant in explaining changes in per capita installed capacity. However, the economic governance index (large scale privatisation and corporate governance with enterprise restructuring) is negatively significant to per capita installed capacity. In most cases, privatisation occurred without an appropriate framework for privatisation itself such as suitable legal structure, a proper regulatory and competition framework. The results, to some extent, indicate the use of power sector privatisation as a 'shock therapy' and with the sole motive of raising revenue. It may be possible to include the lagged EGRI variable in the model to assert this claim and remains a topic for further analysis.

While such privatisation (or the transfer of ownership) indeed raised proceeds for the government, the receipts from privatisation were not necessarily channelled towards adding more generation capacity due to factors such as corruption (Kaufmann and Siegelbaum, 1997). The lack of suitable institution might also have facilitated corruption in the economy. Stiglitz (1999) explains the so-called 'the velvet gloves of privatisation' where privatisation occurred backdoors with ill-motives resulting in mass corruption. Thus, mass privatisation of the power sector with a motive to add generation capacity has defied the logics in the transition countries as per our results in Table 4.8. However, good corporate governance and enterprise restructuring also led to the shutting down of few old and inefficient plants such as Chernobyl in 2001.

Variables	Anderson-Hsiao		Arellano-Bond		Blundell-Bond	
	Model I	Model II	Model I	Model II	Model I	Model II
L.LNPINSTC	0.918*** (0.154)	0.911*** (0.148)	0.924*** (0.030)	0.916*** (0.033)	1.176*** (0.016)	1.16*** (0.018)
PRI	0.006 (0.018)	0.028 (0.074)	0.005 (0.010)	0.015 (0.037)	0.023 (0.015)	-0.018 (0.053)
OIRI	0.007 (0.023)	0.030 (0.060)	0.007 (0.016)	0.035 (0.042)	-0.001 (0.023)	0.083. (0.044)
EGRI	-0.032 (0.020)	-0.091* (0.054)	-.034** (0.013)	-.085** (0.037)	-0.056*** (0.014)	-0.086 (0.047)
OMLI	0.009 (0.021)	0.045 (0.057)	0.009 (0.013)	0.039 (0.034)	0.016 (0.017)	-0.003 (0.044)
FRI	0.015 (0.019)	0.014 (0.076)	0.018 (0.016)	0.003 (0.047)	0.022 (0.290)	-0.024 (0.067)
LNPECS	0.018 (0.037)	0.073 (0.011)	0.018 (0.018)	0.021 (0.021)	-0.018 (0.019)	-0.018 (0.020)
*PRI*OIRI*		-0.017 (0.027)		-0.019 (0.029)		-0.047 (0.022)
*PRI*EGRI*		-0.036 (0.029)		0.031 (0.019)		-0.017 (0.024)
*PRI*OMLI*		-.021 (0.031)		-0.016 (0.018)		-0.017 (0.017)
*PRI*FRI*		-0.002 (0.041)		-0.005 (0.023)		0.022 (0.029)

Table 4.8: Impact of reforms on per capita installed capacity

*, **, *** denote significance at 10, 5 and 1% respectively

4.6.2 *The operational impacts of reforms*

Per capita transmission and distribution network energy losses and per capita overall electricity production were considered as performance outcomes to assess the operational and technical impacts of power sector and other economic institutional reforms. These measures are also helpful in assessing the technical efficiency of electricity generation and transmission.

i) ***Impact of reforms on per capita transmission and distribution (T&D) losses***: The results in Table 4.9 shows that power sector reform '*on its own*' does not have a significant effect on reducing the per capita T&D losses but inclusion of interaction terms in the model would do so. The lagged value is also significant implying prior years' losses have significant bearings on current year's losses. Overall market liberalisation has significantly increased the T&D losses in the transition countries. The argument can be supported on the grounds that cross-border power trade has significantly increased in these countries after market liberalisation. For instance, the SEE region electricity imports increased from 1837 GWh to 5549 GWh between 1995 and 2002 (Hooper and Medvedev, 2009).

The existence of old and long inefficient grids across the transition countries can increase the power losses in proportion with the volume of imported electricity traded. However, overall market reform when complemented with power sector reform has reduced the T&D losses across the TECs. One way to counter the power losses would be to harmonise power sector reforms with overall market reforms (price liberalisation, open trading and competition policy) which also led to efficiency improvements in the regulated networks as shown by the results below.

Variables	Anderson-Hsiao		Arellano-Bond		Blundell-Bond	
	Model I	Model II	Model I	Model II	Model I	Model II
L.LNPTDLS	0.781*** (0.065)	0.783*** (0.066)	0.818*** (0.039)	0.809*** (0.042)	0.928*** (0.031)	0.911** (0.036)
PRI	-0.023 (0.045)	-0.180 (0.135)	-0.018 (0.026)	-0.159* (0.089)	-0.028 (0.027)	-0.191** (0.089)
OIRI	-0.020 (0.059)	-0.053 (0.122)	-0.020 (0.032)	-0.059 (0.076)	-0.009 (0.027)	-0.033 (0.078)
EGRI	-0.004 (0.053)	-0.046 (0.124)	-0.005 (0.032)	-0.048 (0.082)	-0.005 (0.034)	-0.075 (0.084)
OMLI	0.065 (0.046)	0.202** (0.097)	0.060** (0.027)	0.195*** (0.066)	0.058** (0.028)	0.207*** (0.067)
FRI	-0.024 (0.030)	-0.031 (0.161)	-0.026 (0.030)	-0.043 (0.109)	-0.032 (0.031)	-0.025 (0.107)
LNPECS	-0.043 (0.074)	0.053 (0.068)	-0.0489 (0.040)	0.053 (0.043)	-0.034 (0.038)	0.051 (0.040)
*PRI*OIRI*		0.025 (0.059)		0.026 (0.038)		0.023 (0.039)
*PRI*EGRI*		0.029 (0.061)		0.029 (0.039)		0.048 (0.041)
*PRI*OMLI*		-0.106* (0.090)		-0.105** (0.040)		-0.118*** (0.041)
*PRI*FRI*		0.006 (0.081)		0.009 (0.053)		-0.024 (0.036)

Table 4.9: Impact of reforms on per capita transmission and distribution losses

*, **, *** denote significance at 10, 5 and 1% respectively

ii) ***Impact of reforms on per capita electricity production****:* Expansive electricity production was a key economic policy of the TECs. This can be inferred from Lenin's statement that 'communism equals Soviet Union and the electrification of the whole nation'. Table 4.10 reports the results on the impacts of reforms on per capita electricity production after the breakdown of the Soviet Union. Power sector reform significantly affects per capita electricity production only after controlling for interaction across different institutional variables. The past years' electricity production is significant in determining the current year's per capita production across the TECs. Overall market liberalisation seems to have brought about a significant effect in per capita electricity production. Increasing regional power trade with the creation of power exchanges in these countries coupled with increasing cross border trade of oil and gas as a fuel to generate electricity from energy-rich transition countries could explain the overall increase in power trade volumes. Large scale privatisation and enterprise restructuring in relation to power sector reforms also produced significant results in overall electricity production possibly due to new entries in the market as shown in Table 4.10.

Variables	Anderson-Hsiao		Arellano-Bond		Blundell-Bond	
	Model I	Model II	Model I	Model II	Model I	Model II
L.LNPEPDN	0.518*** (0.061)	0.519*** (0.050)	0.578*** (0.030)	0.809*** (0.042)	0.810*** (0.026)	0.848*** (0.029)
PRI	-0.031 (0.082)	0.120 (0.909)	-0.003 (0.015)	0.133* (0.050)	0.015 (0.018)	0.159** (0.089)
OIRI	0.019 (0.101)	0.089 (0.760)	0.019 (0.020)	0.086 (0.044)	0.011 (0.025)	0.150 (0.058)
EGRI	-0.008 (0.100)	-0.073 (0.811)	-0.007 (0.017)	-0.078 (0.047)	-0.017 (0.025)	-0.116 (0.063)
OMLI	-0.007 (0.085)	0.062 (0.645)	-0.002 (0.017)	0.074** (0.037)	0.026 (0.021)	0.084* (0.050)
FRI	0.026 (0.030)	0.010 (1.09)	0.024 (0.019)	0.012 (0.061)	0.019 (0.021)	0.019 (0.077)
*PRI*OIRI*		-0.031 (0.368)		-0.029 (0.021)		-0.067 (0.029)
*PRI*EGRI*		0.038 (0.396)		0.042* (0.022)		0.057* (0.030)
*PRI*OMLI*		-0.055 (0.392)		-0.063 (0.022)		-0.049 (0.041)
*PRI*FRI*		0.013 (0.524		0.011 (0.030)		0.008 (0.036)

Table 4.10: Impact of reforms on per capita electricity production

*, **, *** denote significance at 10, 5 and 1% respectively

4.6.3 The environmental impacts of reform

Carbon emissions intensity (CEI) and per capita renewable installed capacity were considered as the outcome variables to assess the environmental impact of power sector and broader economic reforms since 1990. This measure can serve as a proxy for environmental sustainability to some extent.

i) Impact of reforms on carbon emissions intensity: The empirical results on carbon emission intensity in Table 4.11 show that all institutional variables except for reforms in other infrastructure sectors have no significant bearing on carbon emissions intensity. Per capita electricity consumption in the transition countries has been driving emissions intensity as thermal sources constitute a large share of electricity generation in as shown by our results. Likewise, the previous level of carbon intensity also has a role to play in determining the level of carbon intensity with the lagged coefficient being significant.

Variables	Anderson-Hsiao		Arellano-Bond		Blundell-Bond	
	Model I	Model II	Model I	Model II	Model I	Model II
L.LNCEI	0.892*** (0.040)	0.832*** (0.038)	0.890*** (0.030)	0.866*** (0.018)	0.852*** (0.026)	0.897*** (0.027)
PRI	-0.022 (0.023)	-0.425 (0.393)	0.042 (0.078)	-0.186 (0.069)	0.059 (0.081)	-0.197 (0.027)
OIRI	-0.051 (0.094)	-0.564* (0.029)	-0.115 (0.030)	-0.059** (0.070)	-0.128 (0.027)	-0.553** (0.066)
EGRI	0.193 (0.014)	0.180 (0.034)	0.132 (0.090)	0.0157 (0.052)	0.142 (0.094)	0.148 (0.062)
OMLI	-0.025 (0.013)	-0.134 (0.079)	0.014 (0.078)	0.080 (0.219)	0.033 (0.081)	0.059 (0.224)
FRI	-0.154 (0.140)	0.124 (0.338)	-0.151 (0.119)	-0.056 (0.269)	-0.161 (0.122)	-0.020 (0.273)
LNPECS	0.327* (0.080)	0.323* (0.088)	0.028*** (0.034)	0.338** (0.032)	0.369*** (0.041)	0.353** (0.043)
PRI*OIRI		0.205 (0.047)		0.210 (0.021)		0.192 (0.025)
PRI*EGRI		0.007 (0.060)		-0.007 (0.034)		0.001 (0.037)
PRI*OMLI		0.136 (0.060)		-0.001 (0.030)		0.022 (0.035)
PRI*FRI		-0.179 (0.060)		-0.083 (0.029)		-0.101 (0.043)

Table 4.11: Impact of reforms on carbon emissions intensity

*, **, *** denote significance at 10, 5 and 1% respectively

ii) ***Impact of reforms on per capita renewable installed capacity***: Table 4.12 shows that the lagged value of per capita renewable installed capacity and financial reforms are significant for per capita renewable capacity. Other variables including power sector reforms are insignificant in bringing about changes in per capita installed renewable capacity. The regression results also show that financial sector reforms on their own are important for additional renewable capacity.

The adoption of renewable technology is costly with high sunk costs. Hence, access to credit and availability of finance plays a crucial role. Banking reforms with interest rate liberalisation and the development of several non-bank financial institutions (such as cooperatives) might have facilitated borrowing and much needed access to funds thereby promoting investments in renewable capacity. An important lesson to be learnt from this result is that the long run transition towards a low carbon economy with the widespread adoption of renewable also depends on the overall financial sector reforms in the transition economies.

Variables	Anderson-Hsiao		Arellano-Bond		Blundell-Bond	
	Model I	Model II	Model I	Model II	Model I	Model II
L.LNRPINSTC	1.145*** (0.024)	1.018*** (0.043)	1.076*** (0.016)	1.078*** (0.018)	1.079*** (0.011)	1.078*** (0.012)
PRI	-0.022 (0.023)	-0.121 (0.093)	-0.008 (0.021)	-0.055 (0.069)	-0.008 (0.018)	-0.062 (0.059)
OIRI	0.010 (0.033)	-0.013 (0.087)	-0.004 (0.030)	-0.059 (0.070)	-0.001 (0.027)	-0.063 (0.063)
EGRI	-0.017 (0.023)	-0.067 (0.079)	-0.027 (0.022)	-0.042 (0.065)	-0.026 (0.021)	-0.047 (0.060)
OMLI	0.001 (0.028)	-0.029 (0.067)	-0.003 (0.025)	0.004 (0.059)	-0.004 (0.022)	-0.004 (0.054)
FRI	0.034* (0.030)	0.087 (0.101)	0.057* (0.030)	0.076 (0.082)	0.055** (0.026)	0.093 (0.075)
LNPECS	-0.044 (0.044)	-0.023 (0.048)	-0.028 (0.034)	-0.032 (0.033)	-0.022 (0.031)	0.022 (0.030)
*PRI*OIRI*		-0.001 (0.038)		0.022 (0.032)		0.026 (0.029)
*PRI*EGRI*		-0.018 (0.043)		0.008 (0.034)		0.012 (0.031)
*PRI*OMLI*		0.033 (0.031)		0.004 (0.032)		0.007 (0.029)
*PRI*FRI*		-0.015 (0.049)		-0.015 (0.406)		-0.024 (0.036)

Table 4.12: Impact of reforms on renewable per capita installed capacity

*, **, *** denote significance at 10, 5 and 1% respectively

4.6.4. Summary of results

The results from the econometric analysis reveal that power sector reform '*on its own'* did not directly influence the economic, operational and environmental outcomes. There are two likely reasons to explain such outcomes. Firstly, although reforms advanced linearly in theory; the implementation in practice remained too weak to influence any outcomes significantly. For example, the results indicate that power sector reform on its own has not been significantly linked with change in national income and thereby contradicting the expectations of the policymakers. The legacy of central planning may have translated into slow willingness and commitment towards implementing reform. The first post-communist governments in some SEE (Belarus) and many CIS countries (Turkmenistan and Uzbekistan) were led by the same political elites under communism delaying the progress in transition to preserve the status-quo. Elsewhere in Bosnia and Herzegovina, FR Yugoslavia and Tajikistan; overall reforms including reforms in the power sector have been slow as these countries had to do some 'catching up' due to civil war and ethnic-conflicts. Regional integration via EU membership successfully accelerated power reforms as the countries with common geography, history and culture created appropriate institutions that allowed international integration to complement domestic economic reforms.

Secondly, the complexities and intricacies of power sector reform and dependence on wider economic reform were not properly appreciated or were largely ignored. For example, the results from Table 4.13 below suggest that per capita transmission and distribution losses decrease when power sector reforms are interacted with overall market liberalisation. Likewise, the results suggest that adding new renewable generation capacity is only successful when supported by broader financial sector reforms and reforms in other infrastructures but not with reforms in the power sector. Such results portray the complexities involving power sector reforms and the need to consider wider institutional aspects surrounding these reforms. Thus, the results show that the relationship between power sector reforms and their outcomes in practice is not straightforward as believed in the past by policymakers. On the other hand, the current arrangements of power markets in transition countries with intermediate structures between full vertical integration and full unbundling suggests that the relationship is not linear or at least there has not been a linear path to reform in practice (World Bank, 2011).

Economic performance	Per capita GDP	Positively affected by • reforms in other infrastructure sectors, • economic governance and overall market liberalisation
	Per capita installed capacity	Negatively affected by economic governance
Operational performance	Per capita transmission and distribution losses	Positively affected by overall market liberalisation Negatively affected by power sector reforms and overall market liberalisation
	Per capita electricity production	Positively affected by overall market liberalisation
Environmental performance	Carbon emissions intensity	Negatively affected by reforms in other infrastructures
	Per capita renewable installed capacity	Positively affected by financial sector reform

Table 4.13: Summary of major results

As argued by Stiglitz (1999); it is necessary for policymakers to understand that neither every reform measure is important and nor all reforms should be done at once for reforms to be successful. For example, the results in general show a negative significant relationship between economic governance index and per capita generation capacity even though good governance and enterprise restructuring did shut down few plants. This is mainly due to misguided large scale privatisation under weak governance structure which created and preserved vested interests such as in the Russian power sector. Hence, 'gradualism' with proper sequencing of reform measures can perform better than hastily applied 'shock therapy reforms'.

Two major messages are clear from the results for successful electricity sector reforms in the transition countries: a) the need to harmonize reforms in 'theory' or paper with reforms in 'practice' and b) the need to synchronize electricity sector reforms with other related institutional reforms in the economy. This is because electricity sector reforms fall within the domain of overall economic reforms and is closely interlinked with other sectors of the economy as suggested by the main results in Table 4.13. Thus, in line with Easterly and Levine (2003), the results support the view that power sector reforms where successful and effective are able to do so by adopting broader institutional reforms to support the electricity sector reforms.

However, this analysis may have a number of limitations that are worth mentioning like any other research examining the determinants and impact of reforms. The issue of endogeneity can be raised in this study like all other studies on electricity and economic reforms (Erdogdu, 2011a). Nonetheless, the econometric methodology used in this study controls for endogeneity problems to a large extent. Similarly, this model may not adequately capture and reflect all the qualitative dimensions and steps involved in the electricity reform process. This is because not all aspects of reforms are readily quantifiable in physical and monetary units (Jamasb et al., 2005). The lack of a complete dataset also prevented this study from incorporating other aspects such as technological innovations and changes in energy regulatory regimes to study their impacts on power sector outcomes in the model. It may also be argued that the dataset used in this study did not actually reflect the true reform progress in the transition countries as the reform scores are based on the subjective judgement of EBRD's group of economists. However, the assessment of the scores is based on an updated classification system implying that reform scores may capture actual progress in transition over-time. The analysis also does not quantify the effects of EU membership or candidate status on the performance variables against those transition countries not associated with the EU because of multicollinearity issues involved when using a dummy variable in a small dataset. However, it may be possible to explicitly study the effects of EU membership with a big dataset in the future.

4.7. Conclusions

The aim of this chapter was to explore the link between power sector reforms and their outcomes accounting for wider economic reforms in countries that experienced transformation from centrally planned economic systems towards marketization without effective market signals to market design, tradition, and institutions. The transformation of the power sector was one of the prominent components of this economic transformation because of the economic characteristics of the sector which involved large fixed costs operated by regulated monopolies with alleged significant links with national income and output. Thus, this chapter focused on the relatively ignored role of broader economic institutions that market oriented electricity reform policies tend to rely upon to work.

The results support the view that electricity sector reform is a complicated process primarily due to its dependency upon broader institutional framework in the economy. The link between power sector reforms and other institutional reform have not been as lucid and direct as policymakers anticipated. Thus, failure to understand the institutional aspects of electricity sector reform combined with adopting emulated reforms under differing institutional capacity delayed effectiveness of the process. On this note, it is unclear whether the benchmark set for the transition countries to achieve the standards of that of an industrialised economy such as UK and Norway has been a valid one.

The transition countries seem to have sped up their power sector reforms post 2000 though with stagnation since 2005. While much has been said in the past regarding the pacing and sequencing of power sector reforms; the message from this study is that only those countries that have been able to harmonise reforms across sectors such as harmonizing power reforms with other institutional reforms or are in the process of doing so have gained significantly in terms of power sector and broader macroeconomic reform outcomes. Furthermore, such argument equally applies to many other sectoral reform programmes as well in developing and transition countries.

The errors in the early 1990s across the transition countries sends a message to other developing nations that electricity sector reforms do not perform based on one-dimensional sector-level reforms. The need to formulate realistic reform models based on individual capacity, resources and needs rather than theory driven reforms is what the developing world can learn from the reform experiment in the TECs. The main lesson to be learnt by the developing countries where sectoral reforms and institution building is moving together is that electricity sector reform squarely falls within the domain of wider economic reforms. Thus, power sector reform need not wait until all of proper supporting institutions are in place. However, a more serious problem in power sector reforms in developing countries is that there is often great resistance to them as compared to developed countries, and even when reforms are implemented, the political processes and institutions in developing countries often adapt themselves to counter the effect of reforms in different ways. Hence, the overall health of real-time economic institutions and the rigidity of the institutional framework matters a lot for power sector reforms to succeed as a whole in developing countries.

Chapter 5: Interconnections and Market Integration in the Irish Single Electricity Market

5.1. Introduction

The creation of a common and integrated market for electricity is a major goal of the European Commission (EC). The EU 1996 Directive on ‘Directive for a common Electricity Market’ laid down the foundation for liberalisation and integration of electricity markets in the European Union (EU). The Commission’s Directive 2003/54/EC required the member states to open their markets and guarantee non-discriminatory network access to third-parties while the EU Directive 2009/72/EC placed wider emphasis on cross border-interconnections and the need to mitigate barriers to cross-border trade. As a result, electricity markets across Europe experienced liberalisation, privatisation and price deregulation so as to meet the energy policy goals and targets of sustainability, affordability and security of supply. The development of organised wholesale spot markets and power exchanges, increased cross-border electricity trade and more interconnections, remain the major hallmarks and objectives of these liberalised but largely national markets aspiring to be integrated (Jamasb and Pollitt, 2005).

In line with the EU policy towards greater market integration, the Northern Ireland Authority for Utility Regulation (NAIRU) and Ireland’s Commission for Energy Regulation (CER) began to jointly regulate the all-island Single Electricity Market (SEM) on November 1, 2007. The goal of the Irish All-Island Market (AIM) is to increase investment in new generating plants and availability of existing generators in both the Republic of Ireland and Northern Ireland. However, the isolation of the island's economy from continental Europe has resulted in just one high voltage direct current (HDVC) interconnector link via the Moyle interconnector connecting SEM with Great Britain (GB) amounting to almost 4.7% (about 500 MW) of total SEM generation capacity. The lack of greater interconnection is a major concern in a highly concentrated market as SEM as this can lead to strategic behaviour by the incumbents, creates opportunities for market power abuse and exercise, and unilateral profiting from limited competition in the market. In addition, the potential benefits of an integrated market are not achieved as price convergence can be difficult in the absence of adequate interconnections among the markets.

The main advantages of larger integrated markets are enhanced security of supply and reduction in reserve capacity needed to maintain a given level of system performance (Valeri Malaguzzi, 2009; de Nooij, 2011). An interconnected system is economically justifiable because it incurs lower operating costs by permitting excess supply in one node to be utilised in other nodes where the marginal cost would be higher if there were no interconnections (Charun and Morande, 1997). Thus, the potential for capital cost reduction exists by incurring lower investments as it may no longer be necessary to maintain reserve generating capacity in every node in case of system failures (Turvey, 2006). The total economic surplus is also maximised as the most expensive energy is displaced. Integrated markets, in general, can lead to higher social welfare than if the markets were to remain separate (Neuhoff and Newbery, 2005; Hobbs et al., 2005; Ehrenmann and Neuhoff, 2009). Interconnections between two very similar markets are also desirable for profit-seeking investors as significant revenues can be generated even without consistent price differences between the connected markets (Parail, 2010). Thus, interconnections can create incentives for optimising the size and timing of new investments by linking with a more efficient system (Brunekreeft and Newberry, 2006).

Economic studies on the theoretical and numerical models of strategic behaviour further indicate that it is more costly and hence less attractive to exploit market power in interconnected markets (Amundsen et al., 1998; van Damme, 2004). Interconnection allows generating companies abroad to compete with dominant domestic generators, mitigating market power (Newbery, 2002b). Interconnecting fossil dominated electricity systems such as SEM with hydro based systems could reduce price volatility and mitigate subsequent market uncertainties (Matsukawa and Mulder, 2009). A stable wholesale price, in turn, provides stability to the wholesale market which can further help in providing investment incentives and market signals to the market participants (Green, 2008). Hence, SEM may benefit through increased interconnections with other EU electricity markets in terms of enhanced competition, improved security of supply and lower electricity prices. The increase in competition from interconnections implies that market integration between SEM and other interconnected markets can improve due to wholesale price convergence in the interconnected markets.

The purpose of this chapter is to primarily assess the current degree of market integration between SEM against other large, mature and well-established electricity wholesale markets in Europe including Great Britain (GB) and determine the required level of interconnection needed in SEM to meet the EU policy of increasing integration of electricity markets. In the process, the chapter also estimates the gross benefits for SEM arising from international wholesale electricity price differences and thereby should not be perceived as a cost-benefit analysis (CBA) of interconnection in SEM as the analysis does not explore the cost-side of interconnections and is beyond the scope of this chapter. The analysis believes that competition inherently is the main driver of lower electricity prices in Europe as implicitly underscored in the EU Directives (Jamasb and Pollitt, 2005). Hence, interconnections may be an effective way to increase competition and market integration via price convergence in smaller wholesale markets with limited numbers of participants such as SEM.

The remainder of the chapter is structured as follows. Section 5.2 provides an insight into the Irish wholesale electricity market. Section 5.3 briefly discusses the relevant literature that analyses wholesale electricity market integration in Europe. Section 5.4 describes the features of the power exchanges considered in this study. Section 5.5 discusses the properties of the data. Section 5.6 presents the econometric methodology used in this study. The results are presented in Section 5.7 and discussed with policy recommendations in Section 5.8. Section 5.9 concludes the chapter.

5.2. The Irish Single Electricity Market

The Irish Single Electricity Market (SEM) is a relatively small wholesale electricity market in the European context encompassing approximately 2.5 million electricity customers including 1.8 million in the Republic of Ireland and 0.7 million in Northern Ireland. The installed dispatchable all-island capacity is estimated to be 9356 MW in 2012 while the all-island annual electricity consumption reached around 36.36 TWh in 2011 (EirGrid, 2011). Annual electricity consumption in Northern Ireland alone is around 9 TWh with the peak demand reaching 1669 MW in 2007 while electricity consumption is dominated by household demand (UREGNI, 2009).

The all-island market is operated by SEMO (the Single Electricity Market Operator), a joint-venture between the two transmission operators in Ireland (EirGrid) and Northern Ireland (SONI) respectively. SEM is a centralised gross mandatory pool for any generator with an export capacity of more than 10 MW. All electricity is traded through a market clearing mechanism based on the generators bidding their Short Run Marginal

Cost (SRMC) and receiving the System Marginal Price (SMP). The SMP comprises of two components: shadow price and uplift. The 'shadow' price constitutes the most of SMP as it includes the cost of fuel and the price of carbon. The 'uplift' component has some additional costs tied to the reliable running of the market such as the generator's start-up costs and no-load costs that are indifferent to output levels. In addition, power producers separately receive capacity payments based on available generation capacity and constraint payments for differences between the market schedule and the system dispatch to cover the long-run capital costs. Suppliers purchase electricity from the pool by paying the SMP for each trading period along with capacity payments and system charges.

Economic theory suggests that SRMC pricing is desirable to achieve Pareto efficient outcomes and allocative efficiency by optimally allocating the scarce economic resources at a given time (Hotelling, 1939). However, the risk of social welfare losses or deadweight losses is high in SEM due to the dominance of the wholesale market by two large incumbents, namely Electricity Supply Board (ESB) and Viridian with the potential ability to exercise market power. ESB accounted for a market share of about 80% in 2004 while the Irish state owned 95% of ESB with remaining 5% owned by the employees of the company (Malaguzzi Valeri, 2009). Wholesale market concentration is high as the installed capacity share of the three largest generators in the Republic of Ireland amounted to 95% of installed capacity at the end of 2004 indicating market power concerns and lack of competition. Theory also suggests that market power abuse can lead to productive inefficiency implying that electricity will be under-produced and will no longer be produced at the least possible average cost (Boiteaux, 1965). Furthermore, a vertically integrated market structure between transmission and generation can create incentives and opportunity for exclusionary behaviour making the electricity market more susceptible towards market power abuse (Joskow, 2003). Market power abuse arising from vertical integration can be a major concern for SEM in the events of vertical re-integration (Viridian, 2011).

SEM has a negative pricing regime in place. Negative prices occur in times of high power in feed and in particular from intermittent energy sources such as wind which leads to a lower intersection of the merit-order curve with the demand function leading to lower wholesale power prices (Nicolosi, 2010). Hence, a negative spot price reveals the underlying opportunity costs including the avoided start-up and shut-down costs, and gives higher value to consumer flexibility and provides an additional price signal for the storage of intermittent energy sources such as wind (Geneose et al., 2010). It is further believed that increased trade in renewables in the wholesale market will greatly improve the EU electricity market integration (Joseffson, 2009). This is particularly interesting for SEM as Northern Ireland aims to source 40% of its generation from renewable energy by 2020.

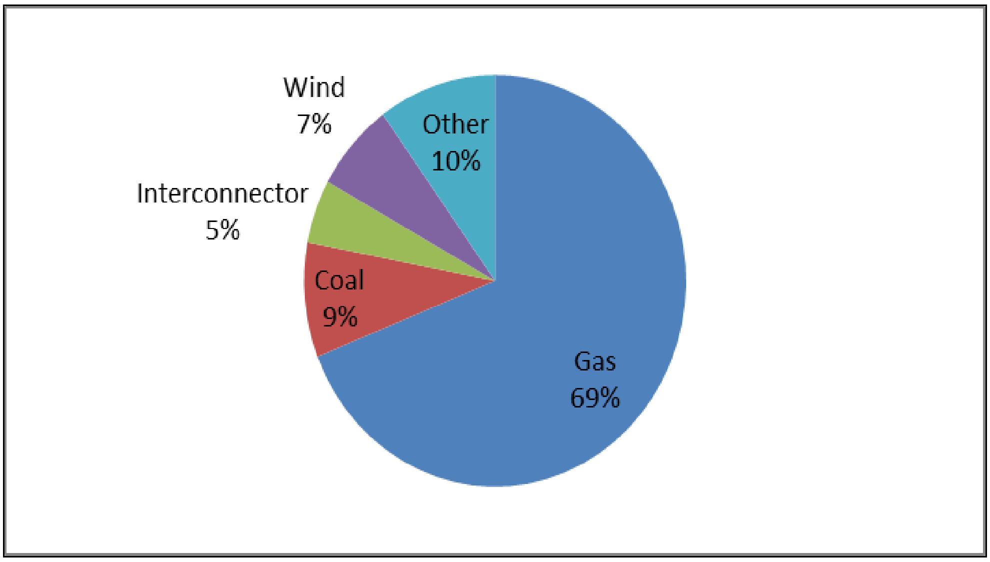

Figure 5.1: Scheduled generation fuel mix for SEM in 2009

Source: UREGNI (2009)

Figure 5.1 shows the scheduled generation mix in SEM for the first three quarters of 2009 spanning from January until September. The diversity in energy mix is dominated by gas fired generation constituting 69% followed by coal and wind at 9% and 7% respectively. The reliance on imported gas and coal mostly from the UK raises security of supply risks in SEM due to high import dependence. This also has an important implication in the SEM wholesale price formation as gas price has been a key driver of the Irish SMP since 2007. The contribution from interconnectors to the generation mix is also set to increase with the planned commercial operation of the East-West interconnector with a capacity of 500 MW joining the island with Wales from 2012. It is expected that renewable energy sources (mostly wind) will replace most of the fossil-based generation in SEM in the future.

5.3. Review of Relevant Literature

Several studies have empirically examined European electricity market integration by studying the development of wholesale electricity price convergence across different European wholesale markets for varying time periods using different econometric techniques. Bower (2002) compared day-ahead 2001 prices from the Nordic countries, the Netherlands, Germany, Spain and the UK applying correlation and cointegration analysis. The study found some evidence of an already integrated market especially among the Nordic countries, the Netherlands and Germany in 2001. Boisseleau (2004) used regression and correlation techniques on the same dataset to determine the level of market integration and subsequently analyses the findings of Bower (2002). The results indicated a low level of market integration among the European electricity markets.

Armstrong and Galli (2005) examined the day-ahead price differentials between Spain, Germany, France and the Netherlands from 2002 to 2004 testing for price convergence. Their findings suggest convergence of European electricity prices during this period. However, Armstrong and Galli ignored the cross-border capacity allocation mechanisms. Turvey (2006) studied the use of interconnectors and pricing of limited transmission capacities using correlation analysis based on the limitations of the study by Armstrong and Galli (2006). The results based on the Anglo-French interconnector indicate a low correlation of flows and price differentials. A recent study by Zachmann (2008) analyses the integration of European electricity prices by studying the development of wholesale prices from 2002 to 2006 and includes congestion charges to account for congestion and congestion management. The findings show that although bilateral price convergence occurred during 2002-2006, no single European electricity market exists so far. The study suggests that congestion charges cannot fully explain the low level of observed market integration using the Kalman filter analysis.

However, none of the above discussed studies on electricity markets have analysed the development of wholesale price in SEM while the occurrence of negative prices in the European Energy Exchange (EEX) and SEM necessitates re-visiting the methodology used in previous studies. Hence, this study examines the degree of market integration of SEM with other EU electricity markets using a dynamic approach to capture the subsequent effect of any structural and unobservable changes (such as political, economic, and regulatory) as revealed through prices over time. Full market integration necessitates that the wholesale electricity prices across markets obey the Law of One Price (LOOP). The law of one price states that in competitive markets free of transportation costs, barriers to trade and infrastructure bottlenecks, identical goods sold in different markets must sell for the same price when their prices are expressed in the same currency (Krugman and Obstfeld, 2003; Burdett and Judd, 1983; Engel and Rogers, 2001 and Lammont and Thaler, 2003).

The prices are analysed because prices aggregate and reveal all market information (Grossman, 1976). Prices should reflect all publicly available information and instantly change to reflect new public information in line with the efficient market hypothesis (EMH) assuming no transmission and distribution constraints (Fama, 1970). According to the efficient market hypothesis (EMH), markets can be weakly, semi-strongly or strongly efficient in terms of reflecting and processing market information. Weak EMH claims that prices on trade already reflect all past publicly available information; semi-strong EMH claims that prices reflect all publicly available information and that prices instantly change to reflect new public information while strong EMH additionally claims that prices instantly reflect even hidden information. Thus, markets become fully integrated as '*an entire territory of which the parts are so united by the relations of unrestricted commerce that prices take the same level throughout with ease and rapidity*' as primarily defined by Cournot (Stigler, 1969). Hence, in a fully integrated market the prices of homogenous products from diverse suppliers should follow the same pattern over time.

This chapter analyses the wholesale spot electricity price development of SEM with other large, mature and interconnected wholesale electricity markets in Europe using a time-varying approach. A low level of market integration would indicate possibilities to improve the integration of markets by expanding interconnections in SEM and accordingly benefit from price differences in international wholesale electricity markets. This is the first study to examine the price development of SEM with other large, mature and interconnected wholesale electricity markets in Europe using a state-space model based on the powerful recursive Kalman filter algorithm while accounting for the occurrence of negative wholesale prices in the spot market.

5.4. European Power Exchanges

Bilateral wholesale electricity trading is the dominant form of wholesale trade in some European countries including GB. The GB power trade is dominated by over-the-counter (OTC) trading since market liberalisation. The operation of the market within the British Electricity Trading and Transmission Arrangements (BETTA) in Great Britain encourages and allows for voluntary bilateral agreements between suppliers, traders and customers (Newbery, 2006). BETTA replaced the New Electricity Trading Arrangements (NETA) in 2005 after Scotland joined NETA while NETA replaced the pool arrangement that existed before 2001. In Germany, around 1900 TWh of wholesale electricity was traded bilaterally in the OTC market in 2005 (Growitsch and Nepal, 2009).

However, electricity trade is no longer confined to OTC trade with the establishment of power exchanges in most European countries. A common market design across many power exchanges is the creation of a spot market in which electricity is traded for each hour of the day based on a day-ahead market except for SEM and GB where trade takes place half-hourly. The wholesale markets in other EU countries besides SEM and GB also consist of multiple voluntary forward and future markets. It is assumed that prices determined in the spot market can contain sufficient information on available generation capacity, supply flexibility, electricity demand levels and demand flexibility (Ulbig, 2010). Analysing high frequency data such as day-ahead hourly and half-hourly spot prices can also avoid the temporal aggregation problems associated with using lower frequency data (such as monthly, yearly) (Hamilton, 1994).

Thus, this study examines the development of hourly and half-hourly intraday prices. The dataset consists of wholesale spot prices from four countries in Continental Europe (Germany, the Netherlands, Belgium and Austria); Northern Europe (the Scandinavian countries including Norway, Finland, Denmark and Sweden); GB and the all-island Irish countries. All of these spot markets except SEM started operation before 2007 while also being large and widely interconnected as shown in Table 5.1. For example, only 1% of scheduled generation in SEM was obtained via the interconnector in 2008 which eventually increased to about 5% in 2009 (UREGNI, 2009). Spot trading of electricity in SEM is mandatory leading to a liquid wholesale market whereas wholesale spot trading of electricity in other power exchanges across Europe is voluntary and bulk electricity is traded bilaterally in the OTC market.

	Countries	Established	Currency	Spot market volume	Total Consumption in 2009	Spot market share (% of total
European Energy Exchange	Germany	2002	EURO	203	581	35%
Belgian Power Exchange	Belgium	2006	EURO	10.1	81.7	12.4%
Energy Exchange Austria	Austria	2002	EUR0	4.7	62.4	7.5%
Nordpool Power Exchange	Scandinavia	2002	NOK	285.5	396.5	72%
Amsterdam Power Exchange	Netherlands	1999	EURO	29.1	122.8	23.7%
APX Power UK (former UKPX)	Great Britain	2000	Pound Sterling	10 (approx)	344.7	2.9%
Single Electricity Market	Northern Ireland and Republic of	2007	Euro and Pound	34.6	36.2	95%

Table 5.1: Characteristics of the power exchanges

Source: Respective spot markets websites ((APX Endex (2011); Belpex (2011); EEX (2011); EXAA (2011; Nord PoolSpot (2011))

A fundamental characteristic common across the power exchanges is the regulatory practice of day-ahead price setting based on ‘sealed bid one-shot uniform price’ auction. The market operator or the auctioneer collects all supply and demand bids while market clearing is done once per trading day separately for each hour besides for GB and SEM where market clearing takes place every half-hour and sold electricity is physically delivered the following day. All bidders essentially receive the same price which is the SMP and any bidder who lowers his quantity offer can improve his terms of trade and the terms of trade of all winners (Klemperer, 2005). However, market participants are only allowed to bid one energy price for an entire day with the exception of interconnection users who bid in half-hourly energy prices while unit commitment is day-ahead in SEM. Bidding one energy price for an entire day serves as a strong market power mitigation device in SEM (UREGNI, 2010).

The European Energy Exchange (EEX) was founded in 2002 as a result of a merger between the Leipzig Power Exchange (LPX) located in Leipzig and the European Energy Exchange (EEX) located in Frankfurt. EEX operates trading market platforms for electricity, natural gas, CO_2 emission allowances and coal. The spot market for electricity is operated by EPEX Spot which is a joint venture owned by German EEX AG and the French Powernext SA since 2008. Hence, the power spot and derivatives market between Germany and France are integrated. EPEX SPOT operates day ahead auctions for spot electricity trade while physical delivery of power takes place on the next day. EPEX Spot also operates an intraday market for Germany and France.

The Belgian Power Exchange (BELPEX) is an organised wholesale electricity trading platform for anonymous, cleared and short term trading which provides a transparent reference price for the market. The Belpex spot market is comprised of a day-ahead market segment (Belpex DAM) and a continuous intraday market segment (Belpex CIM). The Belpex DAM provides standardised day-ahead hourly products for producers, distributors, industrial groups, traders and brokers to sell and purchase electricity to be delivered the day after. The Belpex DAM is coupled to the APX Power NL market and the EPEX Spot day-ahead markets in Germany and France. The prices of electricity on the Belgian DAM are determined via a double-sided blind auction. These prices are also known as market clearing prices. The Belpex CIM provides standardised hourly and multi hourly products for producers, distributors, industrial groups, traders and brokers to sell and purchase electricity on a continuous basis. The Belgian CIM segment is coupled with APX-ENDEX in the Netherlands and Nord Pool Spot in the Nordic region.

The Energy Exchange Austria (EXAA) is a Central European energy exchange and encompasses trading areas in Austria and Germany. EXAA started the day-ahead spot market trading of electricity in March, 2002 and also started trading in European CO_2 emissions allowances (EUAs) from June, 2005. EXAA is operating a day-ahead electricity spot market with a single daily auction point at 10:15 am. This implies that traders are able to place buy and sell orders for electric energy for a day-ahead until 10:15 am when the auction is closed. Traders have the flexibility to choose to buy electricity in individual hours as well as in standardised blocks comprising several hours. The market clearing price is determined during the auction at 10:15 am when the bids are evaluated by a matching algorithm that selects an appropriate price for each hour.

The Scandinavian market has the largest joint spot market for electrical energy in the world (Nord Pool Spot) and organizes a day-ahead spot market via Elspot. Elspot was registered as a separate company in 2002 after Denmark joined the pool. It is also the first wholesale market in the world to trade European Union Allowances (EUAs) for carbon dioxide emissions since 2005. The price formation in Elspot is based on day-ahead auction where power is traded for delivery during the next day. The system price is calculated based on the sale and purchase orders disregarding the available transmission capacity between the bidding areas in the Nordic market. The system price is also the Nordic reference price for trading and clearing of most financial contracts in the wholesale market. However, the settlement of orders in Elspot market is based on the area prices as the market is divided into several bidding areas. A spot market share of 72% indicates that Elspot is highly liquid.

The Amsterdam Power Exchange (APX) was the first electricity market exchange in Continental Europe. APX became APX-ENDEX in 2009 when the European Energy Derivatives Exchange N.V. (ENDEX N.V.) was acquired by APX Group in 2008. The APX Power NL was established in 1999 and provides a spot market trading platform for day-ahead and continuous trading. The trading takes place day-ahead in APX. The market players submit their orders electronically after which supply and demand are compared and the market price is calculated for each hour of the following day. The continuous market provides the members to continuously trade the power products in hourly basis as well as under standardised block of hours up to 90 minutes prior to delivery.

Similarly, the APX Power UK (formerly named UKPX) was established in 2000 as Britain's first independent power exchange. The exchange provides an organised platform for integrated trading, clearing and notification for spot and prompt power contracts and a trading platform for cleared forward contracts. Market clearing price setting is based on a day-ahead auction where trading takes place on one day for the delivery of electricity the next day. The market participants submit their electronic bids after which supply and demand are compared and the market price is calculated for each hour of the following day. The trading and balancing activities at the spot market consists of half hourly products of electricity as well as discrete standardised blocks made up of the individual half hours.

Design aspects	SEM	Other European markets
Number of physical markets	mandatory physical pool-based around single ex-post price	multiple forward and spot markets with voluntary participation
Features of generation bids	complex commercial and technical bids with generators required to bid their short-run marginal cost (SRMC)	bids can be non-complex and simple (covering one hour) or block bids (covering several hours)
Market scheduling and dispatch	central scheduling of generation by optimization algorithm; ex-post central dispatch by TSO; out-of-merit dispatch compensated at the bid price (SRMC)	self-scheduling based on contracted positions; redispatch (by consent) by TSO through voluntary balancing mechanism; balancing actions based on bid-price.
Gate closure timings	currently day-ahead at 10 am for data submissions but scheduling uses out-turn availability, demand and wind generation data	intra-day gate closure is typically within a few hours of real time
Wholesale price composition	separate prices for energy and capacity; no material imbalance exposure	prices reflect a single product with no explicit separation of energy and capacity payments; separate pricing for imbalance exposure

Table 5.2: Market design features across the EU wholesale markets

Source: Based on Poyry (2011)

EEX and SEM are the only power exchanges with negative wholesale pricing regime in this analysis. The EEX allowed the possibility of negative energy prices in bids since September, 2008 and closed with negative prices for the first time in October, 2008. The possibility to trade with dual currencies in SEM makes it a unique organised market in the world. The mandatory pool central dispatch model of the SEM is also an exception in comparison with other EU wholesale electricity markets (Gorecki, 2013). Thus, some differences exist between SEM and other mature wholesale markets considered in this study in terms of market design features such as number of physical markets, form of generation bids, market scheduling and dispatch, timing of gate closure and composition of wholesale prices as observed in Table 5.2 below. These factors are highly significant in terms of facilitating or hindering integration of SEM with other well-established wholesale markets in Europe (Poyry, 2011). However, despite minor differences in market structure and mechanisms, liquidity and products; the EXAA, EEX and APX operate in similar terms (Zachmann, 2008).

5.5. Data

The time frame for hourly day-ahead price data ranges from 1 January 2008 to 31 December 2011 with total number of observations surpassing 35,000 for all markets. The data for APX, EEX, BELPEX, and EXAA was obtained from the German company Energate which hosts the data and information on energy markets. The Elspot data is publicly available while the SEM and APX Power UK data was obtained from external contacts. The hourly day-ahead price data for SEM and GB was constructed by averaging the half-hourly prices within each hour. However, the SEM prices consist of energy only prices while the wholesale prices for other markets also include the capacity payments.

Table 5.3 shows the descriptive statistics of the logarithmic transformed day-ahead hourly wholesale prices across the power exchanges. The SEM electricity prices remain one of the highest in Europe. The day-ahead hourly wholesale prices at SEM were on average 12% higher than APX, 15% higher than APX UK, 16% higher than EEX and 25% higher than Elspot. The heavy use of gas in electricity generation coupled with (or) market power could have led to relatively higher wholesale prices in SEM though this remains to be empirically examined. While the Elspot prices were the least volatile of all; the prices in SEM and GB experienced greater volatility of all markets. The presence of large water reservoirs in Norway and Sweden allow for levelling out the variability of precipitation and in general serve as energy stores for the Nordic system contributing to lower price volatility in Elspot. On the other hand, uncertainties associated with gas prices as both markets have significant gas-fired generation coupled with the underlying trading uncertainty in a new, less mature but liquid Irish market, could have led to high price volatility in SEM and GB markets. However, the log-prices in SEM remained the least volatile after Elspot possibly due to the exclusion of negative prices resulting from excess energy supply from intermittent sources.

Eur/MWh	APX	BELPEX	EEX	ELSPOT	EXAA	SEM	APX UK
Mean	52.18	51.48	49.70	44.46	50.11	59.33	68.17
Median	47.71	47.00	45.98	42.850	46.07	51.77	61.11
Maximum	500.0	500.00	494.26	300.03	248.27	695.8	1111.71
Minimum	0.01	0.01	-500.02	0.000	0.010	-26.02	0.000
Std. Dev.	26.22	24.52	24.45	14.90	23.40	33.84	35.58
Skewness	1.83	1.85	0.69	1.94	1.23	3.14	4.80
Kurtosis	16.79	16.43	22.75	19.01	6.20	24.85	58.33
Observation	35064	35064	35064	35064	35064	35064	35064

Table 5.3: Descriptive statistics (in levels from 2008-2011)

While wholesale electricity spot prices usually show potentially homoscedastic and mean stationary properties at levels; the degree of market integration cannot be observed and needs to be examined. Moreover, changes in time-variant observed and unobserved factors such as fundamental market rules and regulations, new market designs and other institutional changes are likely factors to change the strength of price relationships across markets. This implies that markets either move towards a greater level of integration or they tend to diverge from each other. Hence, the notion of market integration or separation can be analysed by testing for the convergence or divergence of the day-ahead hourly and half-hourly prices across the markets considered in this study.

5.6. Econometric Methodology

The institutional understanding of electricity market integration primarily involves the creation of a common power exchange and elimination of cross-border tariffs while the economic understanding of market integration implies that the prices across markets should be strongly related (Bergman, 2003). Hence, the extent of market integration can be analysed by examining the extent of price convergence across the markets. Price convergence can be explained by a vector of observable and unobservable factors such as the convergence of factor inputs and final product prices; harmonisation of institutional frameworks and electricity market regulation and the convergence of electricity consumption patterns coupled with similarity in generation technologies, trading behaviour and market expectations. Cointegration analysis has been widely used to test for price convergence in the econometrics literature. However, an implicit assumption of cointegration analysis is that the structural relation among prices is fixed over the considered time period. Cointegration analysis ignores the dynamics of any possible price convergence or divergence as mentioned in several studies including King and Cuc (1996) and Neumann et al. (2006). Thus, the assumption of a fixed relationship between spot prices over time seems problematic considering the likely structural developments across all wholesale markets (Growitsch and Nepal, 2011).

This study, therefore, uses a linear state space representation in order to examine the price convergence using the Kalman filter analysis which is based on a recursive algorithm (Kalman, 1960). A Kalman filter can analyse the data series integrated of any order. Hence, the application of the technique has also not been confined to the energy sector of the economy. Karadeloglou (1999) applied the Kalman filter to agricultural prices in Bulgaria and Slovenia. Babetskii et al. (2004) reviewed the pros and cons of an early EU enlargement that included the Central and Eastern European countries using the Kalman filter. Prazmowski (2005) analysed fiscal equilibrium in the Dominican Republic economy using the Kalman filter. Yu et al. (2010) applied the Kalman filter to assess the development of equity market integration in Asia.

The Kalman filter technique is based on a state-space approach. The state space approach incorporates the state variables or unobserved variables to be estimated along with the observable model. The filter allows the nature and path of price convergence across markets to be studied and thereby explains market integration and price efficiency by estimating a time-variant coefficient model. The prices across related markets are efficient to the extent that they already factor in or discount all available information. Hence, efficient prices should also reveal additional underlying information in the market apart from reflecting all available information and reacting instantaneously to new information (Fama, 1970). Using the day-ahead hourly spot prices at SEM (Market A) and other large, mature and interconnected markets considered in this study (Market B), the following equations constituting a linear relationship between the two markets can be specified:

$$P_{A,t} = \alpha_{AB} + \beta_{AB,t} P_{B,t} + \varepsilon_t \qquad (1)$$

$$\beta_{AB,t} = \beta_{AB,t-1} + \Theta_t \qquad (2)$$

where $\varepsilon_t \sim N.i.i.d.(0,\sigma_\varepsilon^2)$ and $\theta_t \sim N.i.i.d.(0,\sigma_\theta^2)$ are white noise processes.

Equation (1) is the 'signal' or 'observation' equation while equation (2) is the 'state' or transition equation. The state equation captures the effect of unobserved variables and incorporates those effects to be estimated with the observed model as represented by the signal equation. In the above set of equations, ε_t and θ_t are normally and independently distributed random error terms (with zero mean and a normal variance σ^2) while α_{AB} captures the time-invariant factors (such as the transactions costs and capacity charges) between the markets A and B. The vector of unobservable coefficients at any time t is denoted by $\beta_{AB,t}$ which describes the price relationship between the two markets considered. Applying the time variant coefficient model to the price series (P_A and P_B) will enable to identify the joint development of prices. It provides information on the value of state variables (α_{AB} and $\beta_{AB,t}$) for each point in time for both price series.

Therefore, the Kalman filter processes the data on both price series in two consecutive steps. It first estimates $\beta_{AB,t}$ by using available information till the period t-1. As a second step, the estimates of $\beta_{AB,t}$ are updated by incorporating prediction errors from the first step as information at time t is realized. In the process, the time variant coefficient model produces linear minimum mean error estimates of $\beta_{AB,t}$ using observed and available data through time t. According to Bomhoff (1992), the coefficients estimated by the Kalman filter generally outperform the coefficient estimate generated by Ordinary Least Squares (OLS) and is hence preferred to OLS. Thus, the filter allows for the updating of the model estimations using newly available information using a specific optimization recursive algorithm (Harvey, 1987; Hamilton, 1994). The filter approach ensures the corrections made in $\beta_{AB,t}$ beyond t (say t+k) to follow a time-varying moving average process of order k-1. The recursive algorithm subsequently updates, or error corrects, the one-step ahead estimate of the state mean and variance given new available information. However, the Kalman filter is the optimal estimate for linear system models and is limited to linear and Gaussian assumptions. This necessitates that the system dynamics and measurement model must be linear in order to apply the Kalman filter analysis.

It is also important to cautiously determine the initial variances for ε_t and Θ_t as well as of the expected value of β_0 to provide suitable noise reduction and signal preservation in the model. In general, the maximum likelihood function has several local maxima implying that inadequately chosen starting points can lead to undesirable results. Exaggerated values of σ_θ^2 would lead to the inclusion of short-term behaviour. This makes it difficult to differentiate random shocks from structural relationships. Likewise, setting the variance too low would ignore significant developments in the convergence process over time (Growitsch et al., 2012). Hence, the following calibration is performed:

$$E(\beta_0) = 1 \approx \frac{P_{A,1}}{P_{B,1}},\ \sigma_\varepsilon^2 = 0.1 \approx Var(P_{A,t}) \text{ and } \sigma_\theta^2 = \sigma_\varepsilon^2 / 1{,}000$$

The initial value for $\beta_{AB,t-1}(\beta_0)$ is chosen to be 1 and not zero given the uncertainty in the initial state estimate. In addition, setting any non-zero initial value would allow the filter to eventually converge. Hence, if A and B spot markets are perfectly integrated, the value of $\beta_{AB,t}$ equals unity at any time t. In contrast, if $\beta_{AB,t} = 0$ the prices of day-ahead hourly electricity traded on both markets bear no relation with each other at any time t implying perfectly uncorrelated prices. This implies that if A and B hourly day-ahead markets are fully integrated or the spot prices are in full convergence, the value of {limit $_{t\to\text{infinity}}$ $(P_A - P_B)$} = α_{AB} while the final state of convergence will be {limit $_{t\to\text{infinity}}$ β_{AB}} = 1. A full market integration indicates limited (or no) opportunity to benefit from cross border price differences through interconnections as arbitrage opportunities become exhausted. In contrast, low market integration implies significant opportunities to benefit from differences in international electricity prices via cross border interconnections and improve market integration accordingly.

5.7. Results

It is necessary to examine the properties and nature of data series as a pre-requisite for any time-series econometric analysis. Testing for unit roots is a well-established methodology in the literature involving time-series. Empirical studies also suggest that unit roots can also be used to test for pair-wise price convergence (or divergence) for price series (Aubyn, 1999; Bernard and Durlauf, 1996; Zachmann, 2008). However, the concept of applying unit roots to test for price convergence can be criticized on the grounds that the stationary property of price differences can mean both convergence and divergence while in the presence of outliers unit root tests can lack power and robustness.

Table 5.4 reports the results from unit root tests based on Augmented Dickey-Fuller (ADF) test (Dickey and Fuller, 1979) and Kwiatkowski; Phillips; Schmidt and Shin (KPSS) test (Kwiatkowski et al., 1992) even though it is not the aim of this chapter to examine market integration via unit roots test. ADF is based upon the null hypothesis of a unit root while KPSS is based upon the null hypothesis of stationarity. The results from both unit roots test are presented as the power of the KPSS test is high as compared to ADF. Double testing also improves the reliability of the results. However, ADF is based upon the null hypothesis of a unit root; the KPSS is based upon the null hypothesis of stationarity. The tests include a constant but no time trend. For ADF, the lag length is selected according to Schwarz Information Criterion (SIC). For KPSS, bandwidth was chosen according to Newey-West using the Bartlett Kernel. The numbers provided in the table denote the t-statistics for ADF and the LM statistic for KPSS.

Electricity hourly day-ahead prices (log)		
Power Exchanges	ADF Test	KPSS Test
	Level	Level
APX	-4.786***	0.358*
Belpex	-7.607***	0.339
EEX	-23.032***	0.353*
Elspot	-2.253**	0.313
EXAA	-51.875***	0.423*
SEM	-37.463***	0.375*
APX UK	-33.42***	0.311*

Table 5.4: Unit root tests

*, **, *** indicate significance at the 10, 5 and 1% levels respectively

The results suggest that the hourly and half-hourly day-ahead price series are stationary at levels and at the first differences. The stationary behaviour of hourly spot prices is expected since electricity cannot be stored economically with demand having little or no effect (inelastic demand). However, the absence of a unit root at levels also precludes the motivation to test for a stable long run equilibrium relation between the price series using the Johansen cointegration test (Johansen, 1998; 1991). The Johansen cointegration test assumes a constant cointegrating vector over time and do not effectively allow assessing the development of market integration over time. However, correlation analysis can be used to determine whether certain market pairs are integrated as the correlation coefficient provides a useful analysis on the initial level of market integration (Stigler and Sherwin, 1985). The correlation results from Table 5.5 show the static notion of market integration between SEM and other large, mature and interconnected wholesale markets.

	APX	BELPEX	EEX	ELSPOT	EXAA	SEM
APX	1.000					
BELPEX	0.963	1.000				
EEX	0.883	0.855	1.000			
ELSPOT	0.398	0.397	0.422	1.000		
EXAA	0.923	0.893	0.927	0.435	1.000	
SEM	0.588	0.560	0.564	0.475	0.602	1.000

Table 5.5: Correlation results (in levels)

The correlation results show that the market integration of Elspot with other markets is the lowest. SEM prices are thinly correlated with other spot markets while price correlation to Elspot is the least. The lack of direct physical interconnection coupled with twin conditions of being a new market and differences in several institutional aspects such as market designs and regulatory framework can explain such low correlation (Poyry, 2011). However, APX and Belpex markets are highly correlated for reasons such as an already existing trilateral market coupling regime between France, Belgium and the Netherlands leading to increased international electricity trade and harmonisation of institutional frameworks. The trilateral market coupling between France, Netherlands and Belgium has been largely successful since 2006. Similarly, the price correlation between SEM and GB half-hourly prices was about 0.52 indicating differences in market structure and arrangements between the Irish and GB markets. The correlation results show some signs of bilateral convergence of prices among different market pairs such as (APX-BELPEX, EEX-EXAA, and APX-EXAA).

However, the notion of a single European wholesale market for electricity still appears far from being achieved.

The relatively low price correlations of SEM with other wholesale markets indicate that significant potential exists to improve market integration from interconnections. Moreover, market integration is a dynamic process and can vary with time due to changes in economic, political and regulatory environment in the national and international energy markets. Hence, results from correlation analysis can be economically misleading as they do not account for changes in market integration process over-time. Table 5.6 illustrates the strength of price relationship between SEM and other large, mature, and interconnected wholesale markets in Europe that are not physically interconnected with SEM based on the Kalman filter using the Maximum Likelihood estimator (MLE) for the log prices. The log prices can better reflect the underlying distribution of the residuals used in the model. Log transformed prices also potentially mitigate the heteroscedastic properties of prices by minimising the effects of high volatility and the outliers.

The results show the current state of market integration of SEM is less than 20% with most of the other studied markets while being insignificant. Hence, the results suggest absence of any market integration of SEM with EEX, APX, Belpex and EXAA. However, the results interestingly suggest a low degree of market integration (0.19 out of the possible value of 1) between SEM and Elspot even though these markets are not physically interconnected. The existence of liquid and transparent wholesale markets coupled with reliable day-ahead market arrangements might have facilitated the market integration process between SEM and Elspot. Liquid and transparent wholesale electricity prices facilitates the price convergence process by quickly reflecting and processing all available public information contained in prices as suggested by the semi-strong efficient market hypothesis (Fama, 1970; Cargill and Rausser, 1975). Liquidity also remains an important feature of a well-functioning wholesale market (DECC, 2011). Hence, the SEM and Elspot markets possess a common feature of quickly absorbing and responding to all available public information and thereby facilitating the market integration process as both of these markets are liquid. This finding supports the results by Zachmann (2008) in concluding that higher wholesale market liquidity can accelerate the price convergence process across related markets.

However, this is an indicative result and further research is required to examine the exact impact of wholesale market liquidity on wholesale market integration.

Method: Maximum likelihood (Marquardt) Sample: 1/01/2008 to 12/31/2011	
Market Pairs	Final State of Market Integration
SEM-EEX (log)	0.09 (0.069)
SEM-EEX (levels)	0.29 (0.413)
SEM-APX (log)	0.18 (0.058)
SEM-APX (levels)	0.45 (0.460)
SEM-Belpex (log)	0.15 (0.058)
SEM-Belpex (levels)	0.44 (0.432)
SEM-EXAA (log)	0.14 (0.057)
SEM-EXAA (levels)	0.47 (0.464)
SEM-Elspot (log)	0.19*** (0.061)
SEM-Elspot (levels)	0.27 (0.512)

Table 5.6: Market integration coefficients (in logs and levels)

*, **, *** indicate significance at the 10, 5 and 1% levels respectively

Numbers in brackets report the root mean squared errors

Table 5.6 also calculates the market integration coefficient based for price levels for the same market pairs to better understand the role of wholesale renewable electricity trade in wholesale market integration. The levels prices include the negative prices as well which is an important element of wholesale market design in EEX and SEM. The results show a large improvement in the final state of market integration coefficient for all market pairs after the inclusion of negative prices. The availability of more market information through negative prices might have resulted in such an increase. However, the results are not significant indicating no market integration. The results based on the existing dataset do not support or remain inconclusive in claiming that increasing renewable wholesale trade will lead to an increasingly integrated market for electricity in Europe.

Table 5.7 presents estimate of market integration coefficients between the large, interconnected and mature electricity wholesale markets considered in this study in order to facilitate comparison and establish a benchmark case of market integration between SEM and other markets. The results, using the unitary method, illustrates the corresponding level of interconnection required in SEM to reach the integration level of other well established wholesale markets in Europe considering that interconnection amounts to only 4.7% of available generation capacity.

Method: Maximum likelihood (Marquardt) Sample: 1/01/2008 to 12/31/2011		Required level of interconnection in SEM (as a percentage of total generation capacity)	
Market Pairs	Final State of Market Integration		
APX-Belpex	0.77*** (0.008)	APX 19%	BELPEX 20.10%
EEX-APX	0.66*** (0.013)	EEX 25.9%	APX 16.33%
EXAA-APX	0.86*** (0.006)	EXAA 26.9%	APX 21.3%
EXAA-EEX	0.62*** (0.0110)	EXAA 19.42%	EEX 24.3%

Table 5.7: Market integration coefficients among selected markets (log prices)
*, **, *** indicate significance at the 10, 5 and 1% levels respectively
Numbers in brackets report the root mean squared errors

Hence, if SEM is to achieve the market integration coefficient of 0.77 that currently exists between APX and Belpex all other things remaining constant; 19% of the generation capacity should be met by interconnecting with APX or 20.1% with Belpex. If SEM wholesale prices converge to the levels EEX, APX, Belpex, EXAA and Elspot; the expected gross benefits to SEM arising from international price differences would amount to about 333, 248, 272, 319 and 514 million euros respectively. The estimate of gross benefits was obtained by multiplying the 2009 spot market consumption of the total demand from Table 5.1 with the average hourly wholesale price differences between SEM and all other markets assuming a constant annual total demand. The benefits arising from international price differences to SEM can guide policymaking involving the cost-benefit analysis of interconnection in SEM even though physical interconnection with other European markets can be expensive for SEM. These estimates can be an important input for policymakers undertaking the social cost-benefit analysis of interconnecting SEM with these markets.

However, it is likely that SEM will be further linked to GB as the two markets are already physically interconnected. Hence, this study also estimates the current state of market integration between GB and SEM using the half-hourly spot prices accounting for the negative wholesale prices in SEM. Table 5.8 shows the market integration coefficients for SEM and GB which evidences the existence of an integrated market between SEM and GB. The current market integration of 17% indicates that an engineering capacity of 2941 MW is required to achieve 100% market integration between GB and SEM with all other things remaining constant. Full market integration would generate a gross benefit of about 306 million euros in SEM arising from the competition effects between GB and SEM markets.

Method: Maximum likelihood (Marquardt) Sample: 1/01/2008 to 12/31/2011	
Market Pairs	Final State of Market Integration
SEM-GB (log)	0.17*** (0.04)
SEM-GB (levels)	-0.41 (0.460)

Table 5.8: SEM-GB market integration coefficients (in log and levels)

*, **, *** indicate significance at the 10, 5 and 1% levels respectively

Numbers in brackets report the root mean squared errors

The results also indicate the market integration between SEM and GB with a direct physical connection is less than the market integration between SEM and Elspot even without a direct physical interconnection. This could be primarily because of the illiquidity of the GB market implying that the market is not fully able to capture all available market information via prices. Liquidity in the GB wholesale market has declined since 2001 primarily because the major vertically integrated players owning both generation and supply can sign confidential bilateral contracts with retailers outside the wholesale market (DECC, 2010). It also indicates that the Moyle interconnector may not be efficiently used to generate any substantial effect on market integration between SEM and GB. Likewise, the market integration coefficient remains insignificant after including the negative prices making the contribution of renewable energy trade to market integration inconclusive.

Figure 5.2 shows the path of the market integration coefficient ($\beta_{AB,t}$) between GB and SEM markets since November 1, 2008. It can be seen that the coefficient has remained seemingly volatile primarily due to series of market events and announcements in the GB and SEM markets. The introduction of Moyle access arrangements and capacity allocation procedures in 2008 could have produced this effect even though it requires examining in a detailed event study.

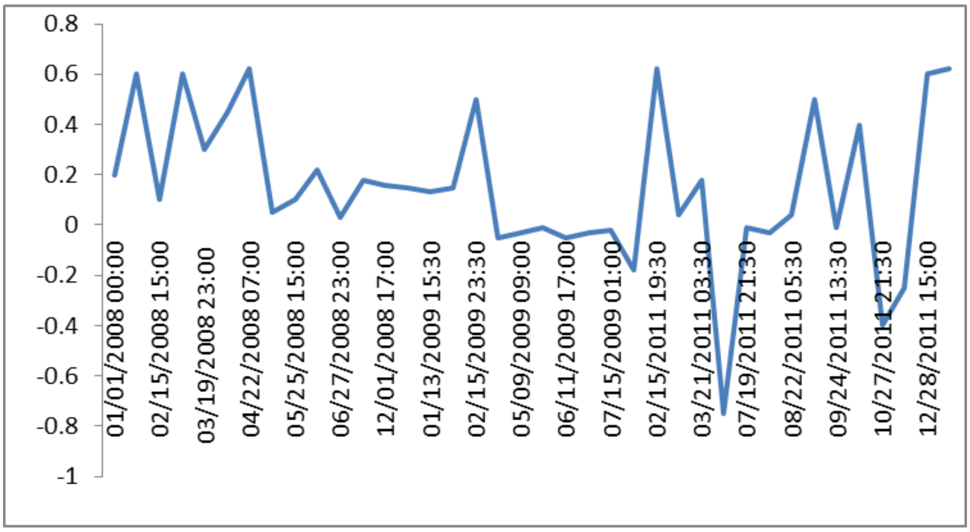

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Figure 5.2: Path of time varying coefficient ($\beta_{AB,t}$)

The results from CUSUM plot in Figure 5.3 show that the markets experienced several structural changes since the third quarter of 2008. The market integration coefficient has reached as high as 0.6 while also hitting as low as -0.7. The integration coefficient remained volatile and unstable over time and far from reaching unity which can primarily be attributed to various uncertainties such as trading and volatility associated with high liquidity in a newly established market. However, higher price volatility can be an inherent feature of a liberalised energy market where prices quickly adjust to market volatility and shocks.

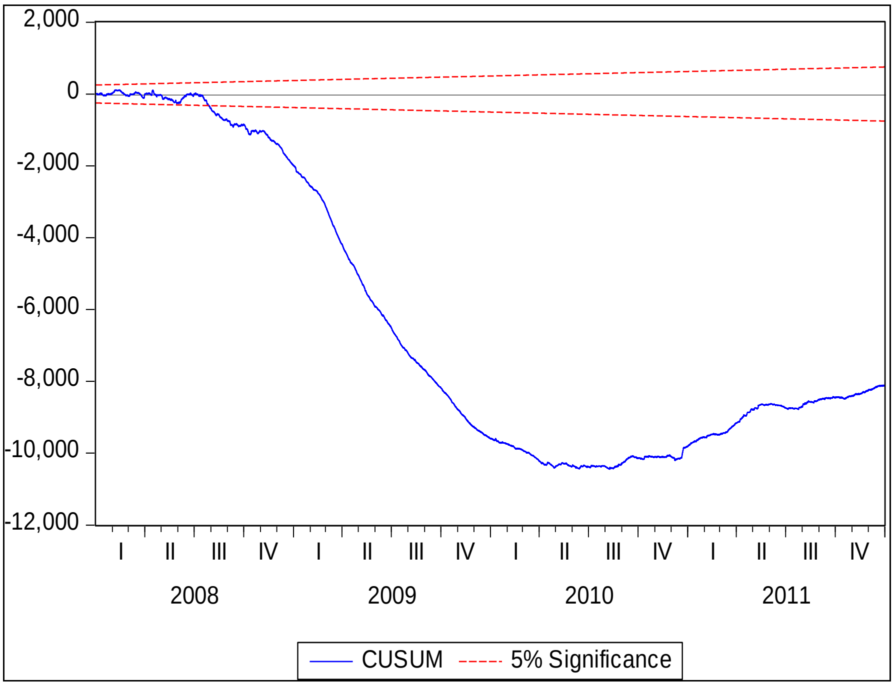

Figure 5.3: CUSUM plot for assessing structural changes

5.8. Discussions and Policy Recommendations

The low levels of market integration and relatively higher average wholesale prices in SEM as compared to other wholesale markets in Europe including GB indicates significant potential for wholesale price reductions in SEM from increased interconnection. The transition towards a low-carbon economy has meant that the Irish government has a target to achieve 40% of energy consumption from wind energy by 2020. Expanding interconnections will enable SEM to effectively utilise the growing wind generation by exporting to BETTA and other markets as there are physical limitations to the amount of wind that can be accommodated within the SEM. Hence, the proposal to expand the interconnection network through the East-West interconnector (Ireland-Wales) apart from the existing Ireland-Northern Ireland interconnector (Louth-Tandragee) and the existing 500 MW Northern Ireland-Scotland interconnector is desirable. However, an interconnected system also bears certain security of supply risks as the damages in one region can easily spread along the interconnected regions via the interconnector creating a ‘ripple effect’ (Hammond and Waldron, 2008). Interconnecting markets with a growing share of diverse and intermittent wind generation can pose additional security of supply challenges to the grid and system operators due to system imbalances and inadequate system harmonisation.

The market integration results suggest the availability of interconnector capacity and efficiency of interconnection usage to be significant in affecting the level of market integration. Furthermore, efficient interconnection usage can contribute to high liquidity even in the presence of a fair amount of vertical integration among electricity companies as suggested by Germany and Norway. However, Gebhardt and Hoffler (2013) showed that it is rather the lack of competition, a case where well-informed traders do not engage in international electricity trade, than the presence of limited interconnector capacities that explains the significant difference in average international electricity prices across Europe. This indicates that inefficient use of interconnector capacity remains a major problem in the liberalised electricity markets in Europe. De Nooij (2011) also mentioned that a capacity worth almost 50 million euros was not utilised in the German-Dutch interconnector in 2004 while underutilisation and misuse led to a loss of 289 million euros in the UK-France interconnector from 2001 to 2005. Hence, it is desirable that the existing interconnector capacities between SEM and GB are efficiently used while GB also expands interconnection to mainland European electricity markets.

Market coupling can be an appropriate mechanism to efficiently utilise existing interconnector capacity and improve market integration. Market coupling will allow wholesale market participants to benefit from cross-border exchanges without needing to explicitly acquire the corresponding transmission capacity. Transmission capacity is automatically used to the maximum extent possible and surplus capacities will be made available for reallocation. This implies that market coupling also reduces potential for hoarding capacity. The market coupling mechanism allows different wholesale markets across countries to be coupled in a manner that requires them to make minimal changes to their market rules while maximising the total economic surplus of all participants. This is because cheaper electricity generation in one market can meet demand and reduce prices in another market while the markets will converge entirely when there are no transmission constraints. Market coupling, thus, represents a major step towards a more integrated European market. Hence, the proposal to couple SEM with GB and French markets by 2014 seems desirable in integrating the SEM market with mainland Europe while additional market coupling possibilities with other continental markets should also be explored.

Reform of the UK electricity market implies that GB is set to introduce the carbon price floor from April, 2013 to ensure the viability of long-term contracts. Long-term contracts would reduce the risk and assure the market and the new entrants of a future revenue stream and encourage investments towards low-or zero-carbon generation. Hence, the introduction of a carbon floor price may lead to a tax reflecting the difference between the carbon floor price and the EU's European Trading Scheme (ETS) price. That price cannot be readily reflected by the existing SEM rules and thereby presents a problem. In addition, this raises questions about whether the costs should be absorbed by Northern Ireland generators or if Ireland will have to introduce a similar carbon price. It is desirable that the Republic of Ireland also adopts the carbon price floor to mitigate any fiscal disadvantage with Northern Ireland. It would be interesting to assess the the impact of carbon price floor introduction on market integration between GB and SEM with a longer time-series data accounting for future changes in market rules and regulation.

The future regulatory environment surrounding wind energy also needs to be examined as wind generation is set to increase in SEM and the rest of Europe. It is desirable that tradable permits for wind generation are established so that surplus wind electricity generated in Ireland could be traded to another market with a deficit leading to a more efficient allocation of resources. This could also be a viable option for managing the wind energy to be generated across the EU in the future. However, exporting wind electricity generated from Ireland also means that consumers in other markets are benefiting from wind subsidies in the SEM market and appropriate arrangements are needed to address the free-rider issues without disrupting the electricity generation from wind.

5.9. Conclusions

The aim of this chapter was to examine the impact of interconnections on market integration in the all-island Irish electricity wholesale market. SEM is a small isolated market with a relatively small number of market players and thereby operating under an oligopolistic market structure. Oligopolistic market structures are typically not considered to be competitive and can lead to anti-competitive outcomes under limited competition. Hence, market integration of SEM with other markets can be desirable to prevent any anti-competitive market outcomes in SEM. A time-varying econometric technique based on the Kalman filter algorithm was applied to determine the degree of market integration between SEM and other large, mature and interconnected wholesale electricity markets in Europe including the GB market.

The results show that market integration of SEM with other wholesale markets around Europe excluding Elspot and GB do not exist largely due to the absence of direct physical interconnection between these markets. However, the results show a low evidence of market integration between Elspot and SEM despite any direct physical interconnection between these markets. This indicates that unobservable factors such as market liquidity may be a crucial factor in facilitating wholesale market integration and requires further research. The results also suggest low market integration between SEM and GB despite a direct physical interconnection between these markets. This indicates the need to expand interconnections between SEM and GB while efficiently utilising the existing interconnector capacities.

It is desirable that SEM reduces its reliance on expensive gas firing and increase generation from alternative energy sources as the average wholesale prices in SEM are high and volatile as compared to other markets in Europe. As such, the Republic of Ireland has a target of generating 40% of electricity from wind by 2020 which seems appropriate and forward looking. However, the Kalman filter results remain inconclusive in determining whether trading intermittent energy sources such as wind can contribute towards market integration unless other complementary conditions such as storage, proper regulatory and market design framework are established. Nonetheless, it can be expected that an increasing share of wind energy in the generation mix across Europe will improve the wholesale market integration as generation technologies converge. This will require further research.

The results also showed that the gross benefits to SEM from wholesale price convergence with other European markets are large. This indicates that interconnecting markets and increased trading of electricity on a level playing field via a common platform such as power exchange can offset the problems of potential market power abuse and increase competition in the wholesale market. Increased interconnections will also increase the security of supply benefits and reduced price volatility apart from the benefits of lower prices as markets integrate. For example, price volatility in Elspot is lowest because of increased cross-border electricity trade with the integrated markets even though the region is dominated by seasonally varying hydro generation. This implies that integrated markets can still pursue interconnections expansion to improve security of supply and mitigate price volatility.

However, increasing interconnections will require major investments in interconnector capacity and transmission networks. Thus, it is desirable that interconnections with other larger wholesale markets in Europe such as Elspot are considered based on careful cost-benefit analysis. Interconnecting markets and improving market integration will also require some harmonisation of economic and regulatory institutions across countries which can be challenging. However, if properly done, the gains can be significant as demonstrated by the NordPool experience. Other important factors include establishing appropriate regulatory frameworks and market design that incentivizes wholesale market participants to actively engage in cross-border electricity trade as well as optimally utilising the interconnector capacity and generating adequate investments in transmission infrastructure.

Chapter 6. Conclusion

6.1. Summary

This thesis qualitatively and quantitatively assesses the evolution and impact of market-driven reforms evolving the electricity sector of less-developed, transition and developed countries based on cross-country econometric and case studies. The countries studied include Nepal, the transition countries and the all-island Irish economies. Deriving relevant and feasible reform options and policy recommendations for the electricity sector based on the lessons learnt after considering more than two decades of power sector reforms in these countries is the major aim of this thesis.

Electricity sector reforms in Nepal started in the early 1990s often as a result of direct pressures from international donor organisations. Nepal is a developing country in South Asia with a small electricity sector and has only pursued minimal power sector reforms. The state is actively involved in the operation and management of the power sector in Nepal. The transition countries include both developing and developed economies with electricity sectors of varying size and have pursued minimal to full adoption of the standard reform model. These countries experienced power sector reforms in the context of overall market-oriented macroeconomic reforms in the economy. The role of the state in power sector ownership and control significantly varies among the transition countries. Ireland and Northern Ireland have fully adopted the standard reform model with the joint operation of a small organised wholesale spot market for electricity. The successful reform experience in the UK with market-based models provided the early impetus for reforming the all-island electricity markets. Hence, the role of the state in power sector operation and management remains limited in the presence of independent regulatory authorities across the island.

The analysis of electricity reforms among countries studied in this thesis suggests significant heterogeneity in the power sector outcomes even though all of these countries adopted the standard reform model to some extent. Reforms appear to have led to some improvements in efficiency gains in the electricity sector of reforming countries when implemented properly even though the direct benefits of reforms to end consumers remain less visible. The governance of the electricity sector has also improved in developing and developed countries where independent regulation has been effective. Likewise, the prospects of competition and innovation in the sector have improved with the proper implementation of reforms. For example, Guatemala has a competitive wholesale power market with a capacity of 1875 MW while the small joint Irish market in the European context is expanding interconnections to reap the benefits from deepening competition in the wholesale market. However, it is not clear from the findings of this thesis that the application of the market-driven reform process has been a global success after nearly three decades of reforms and restructuring of the electricity sector. This necessitates a careful understanding of the lessons and policy implications of electricity reforms based on liberal market-oriented policies.

6.2. Lessons and Policy Implications

Academics, policymakers and practitioners in favour of the standard reform model may generalise the success of reforms in pioneer reforming countries such as NordPool, UK, Chile and other LACs such as Argentina, Colombia and Brazil in concluding that market-based reforms can be successful when implemented properly. These LACs preferred to pursue competition and privatisation of the electricity sector as opposed to the single buyer model with public ownership prevalent in most South Asian countries such as Nepal. In contrast, those critical of the reform process can generalise the outcomes of the slow and unstable market-based reforms in Eastern Europe, Asia and Africa in concluding that the reform process has been costly, unsuccessful and economically wasteful.

The severe market failures that occurred in the liberalised Californian electricity market during 2001-2002 and popularly known as the California crisis marked a turning point in the progress of electricity and gas market liberalisation in the US and cannot be forgotten. The UK reform experience has also revealed considerable complexities and difficulties in making market driven reforms work when the global trend towards electricity reform is driven by orthodox political ideologies and theoretical arguments in favour of market-oriented reforms for nearly two decades (Newbery, 2012). Hence, it is necessary to draw out relevant lessons and policy implications of reforms in terms of 'what needs to be done' and 'what needs to be avoided' based on the reform discourse observed from different reforming countries at varying stages of the market-oriented reform process and economic development.

6.2.1. Reform in developing countries

Many developing countries such as Nepal face continued major challenge of meeting their electricity demand driven by economic growth and increasing population. The inelastic demand for electricity from industrial and residential consumers has resulted in rolling and frequent power outages under tight electricity demand and supply conditions. The electricity prices are not market clearing as market determined prices are not politically desirable even though some elements of market-based reforms are introduced in these countries. This implies that electricity prices will have to rise from uneconomic levels in developing countries. Moreover, electricity price reforms have always presented a complex dilemma for developing countries. Politically determined low electricity prices can be essential in these countries to maintain social equity and increase affordability among the dominant poor population although not being economically efficient and desirable. Thus, any attempts to radically increase the electricity price can be unsuccessful in the absence of a cautious balancing mechanism between economic efficiency and social equity. For example, it is prudent that price adjustments be done before privatisation rather than after privatisation for socio-economic reasons if privatisation of the electricity companies is considered as an option for reform in less-developed countries. Lessons from LACs suggest that the mass public opposition to privatisation arose due to the failure of the liberalised reform process to deliver for the poor while being linked to bad governance and corruption (Roland, 2008).

Electricity sector reform and restructuring is a costly process and successful adoption of market-based reforms should not be taken for granted by developing countries. It may not be necessary for less-developed countries to pursue radical restructuring of their electricity markets based on the standard textbook model as many countries such as Norway, Brazil, China, France and US have historically succeeded and still continue to do so in developing their electricity sector with publicly-owned companies. Governance improvements are crucial in these countries to control corruption and the issues of non-payment. Improvements in governance are also necessary in order to have independent regulation in place in case of reforms being adopted. Thus, corruption control together with skilled work force enrichment and carefully determined sustainable electricity prices may be more essential in some developing countries rather than the electricity reforms proposed by the standard model.

However, it is clear that proper implementation of reforms in developing countries such as Argentina led to a significant increase in investments in generation and network expansion while Colombia gained major power efficiency in distribution and foreign investment. In countries like Peru and Brazil, access to electricity and labour productivity in distribution and supply companies improved respectively after the introduction of market-based reforms in their electricity sector (Millan, 2006; Anaya, 2010). Therefore, the application and sequencing of electricity sector reforms in less-developed and developing countries is largely country-specific depending on individual country needs and priorities and should not be driven by the *'keeping up with the Joneses'* principles. The LACs reform experience also suggests significant benefits of increased competition from the adoption of the market-based model as market grows. Hence, small countries like Nepal may benefit from full adoption of the standard reform model by expanding interconnections with other South Asian countries and increasing the size of the market. An integrated South Asian regional market for electricity can be an option for small economies like Nepal with high electricity generation potential in the long- run.

Moreover, the lack of adequate network investments will be a critical issue for developing countries even though the current major concerns with reforms are mostly associated with generation adequacy and easing capacity shortage. It is inevitable that the existing grid in these countries cannot accommodate all electricity generated as generation continues to expand to meet growing demand. Further, the gradual switch towards renewable energy sources will exert additional pressure on the existing grid in terms of integrating generation into the transmission and distribution networks unless re-designed and updated. For example, the Indian power crisis that occurred during July in 2012 affected around 700 million people and halted the functioning of several other critical infrastructures after a two-day blackout. The blackout experience teaches a valuable lesson for developing countries to also invest in power infrastructures and effectively manage demand in meeting the growing electricity demand spurred by economic growth.

6.2.2. Reform in transition economies

In transition countries, electricity sector reforms occurred along with reforms in other sectors of the economy. Hence, electricity reforms became a mixed priority due to the need to focus reforms in other sectors of the economy as well. This could be a major reason for the observed heterogeneity of reforms implemented across the transition countries with mixed success stories. Those aspiring to join the EU have pursued more far-reaching reforms such as retail market opening and the creation of a spot market in their wholesale market while those in Asia such as Turkmenistan, Uzbekistan and Belarus are still struggling with early stages of reform. Most importantly, it is not clear among the transition countries whether the advanced reformers have significantly benefited from market-driven reforms than the slow reforming or non-reforming countries.

This is possibly because power sector reforms in transition countries were not well-targeted as they missed the third major element of the standard model which focussed on creating powerful and effective new institutions such as independent regulation. The neo-classical belief that institutions 'do not matter' did not hold true in power sector reforms of the transition countries while all other successful reformers like UK, Chile and Norway had well designed economic institutions in place to buttress market-based reforms in the electricity sector. Hence, the reform experiment in the transition countries teaches an important lesson to other developing countries, that structural changes take time to implement and to produce desired effects. This implies that it is important to envisage a suitable industry structure from the start of the reform. It is essential that appropriate governance mechanisms be put in place so that the social and institutional capacities of the country are able to support the reforms being implemented in the power sector. A better understanding of the energy sector political economy needs to be developed in developing and transition countries to adequately inform the reform design and process.

The evidence of reforms from transition countries provides a clear lesson that the success of electricity reforms can depend on the willingness to change, learn and adapt to new information and problems. Political ideology often has proved to be a stumbling block in power sector reforms flourishing among these countries as demonstrated by the group of Caspian countries. Hence, political objectives should not be prioritised at the expense of sound economic principles while the political-economy arrangements in these countries should facilitate the reform process in the electricity sector as a whole. Likewise, social legitimacy and public acceptance of reforms are crucial in tackling the traditional problems of power theft and non-payment in most of the transition and developing countries.

Social legitimacy and public acceptance of reforms can be increased if adopted reform programs adequately reflect the local or country-specific economic, political and social conditions shaping the power sector rather than solely holding to a reform ideology that proved successful elsewhere. Thus, it is not clear if market-centred EU electricity reform model which is in a trial phase across the EU-25 is the best reform model for all transition countries. It is essential that development policymakers not rely on formulaic economic or systems models for power sector reform in developing and transition countries. Similarly, the small size of the electricity market in some SEE countries like Albania, BIH, Romania and Montenegro indicate that these countries need to expand interconnection to reap the benefits of increased wholesale competition from the adoption of the market-oriented economic reforms.

6.2.3. Reform in developed economies

In developed economies such as the EU, electricity reforms have reached advanced stages with major elements of the standard reform model being already implemented. Many developed economies have already established wholesale spot markets for electricity. To some extent, the EU electricity market reform process is unique because it allowed for retail competition from start in the form of market opening. However, differences exist among EU countries such as in France and Germany where both economies have 100% market opening in principle but the practice of market opening and consumer switching suppliers is irrelevant in France where regulated customers benefit from low electricity prices due to large nuclear generation and national subsidies. Likewise, the French electricity industry is still heavily vertically integrated as generation, transmission and supply have not been separated indicating a deviation from the standard reform model.

Elsewhere such as in the Netherlands, the industry is vertically separated and the transmission network is ownership unbundled. The distribution segment is legally unbundled from the competitive segments. Similarly, energy sector private ownership has been pervasive in economies like Germany, the US and Japan throughout the post-

World War II period while substantial public ownership has persisted within liberalised energy sector in economies like Norway, Sweden, New Zealand and Australia (Pollitt, 2012). Nonetheless, the creation of a single integrated market for electricity is a major objective across the EU as driven by the Lisbon Agenda of 2010 and reinforced by the three European Directives. It is, however, essential to understand that achieving full market integration across the EU still requires harmonisation of the economic and institutional aspects governing the regionally integrated but yet separate cross-border markets.

The creation of organized spot markets such as power exchanges and removal of cross-border trade barriers has facilitated the economic integration of wholesale electricity markets across the EU creating separate regional trading blocs. However, day-ahead wholesale electricity price differences are still large among countries like Ireland and UK as compared to the prices in NordPool countries such as Norway and Sweden (Meeus and Belmans, 2008). Incompatible differences also exist in the form of market design and structure among the different transmission system operators (TSOs) and the spot market operators. Electricity reform lessons from NordPool, which runs the largest spot market for electricity in the world, suggest that market integration is largely dependent on establishing similar institutional and economic arrangements as exists within the Nordic countries. However, the regulatory environment and the governance structures vary widely across the EU markets. For example, the French electricity industry operates on a more hierarchical structure where the Ministry assumes a greater control in terms of responsibility allocation among the regulatory authorities. On the contrary, the Dutch electricity industry is operated under market based governance with greater control from the independent regulatory agency and the competition authority (Niesten, 2006). The incompatibility among these unobservable institutional factors should not be overlooked as they can significantly delay the creation of a single integrated market for electricity in Europe.

Increased investment in transmission networks and transmission infrastructures connecting the cross-border markets coupled with an efficient allocation and usage of transmission capacity is essential among the EU electricity wholesale markets to improve market integration among them. This is particularly true for small isolated regions and island economies in the EU such as Ireland. The transition towards a less carbon intensive energy-economy, increasing digitisation of the grid, (the so- called smart grids), larger adoption of renewable energy and the growing integration of electric vehicles also implies undertaking the capital-intensive tasks of maintaining and re-designing the existing grid to accommodate these technological transitions in the networks. It is estimated that the transition towards a sustainable and smart energy economy will require investments of about 200 billion euros in electricity and gas transmission networks (Vinois, 2012).

However, the lack of adequate investment in both transmission and distribution networks is a major regulatory issue of the modern day liberalised market structures in the EU built on the standard reform model. The on-going quest towards the creation of a common internal market of electricity can depend on the ability of the EU electricity markets to innovate the required level of investment in the networks and cross-border infrastructures. This remains a major challenge in the absence of an appropriate regulatory framework and adequate institutional harmonisation across member states. However, increased investments and a significant rise in grid related capital costs will necessitate a rise in consumer electricity bills. Rising end-user electricity bills can be a major concern for countries like the UK where around 4.75 million households experienced fuel poverty in 2010 (DECC, 2012). Hence, developed economies also face a major challenge and need of balancing economic efficiency and social equity as in less developed and developing countries. However, developed countries may find prices falling due to reform and have the capacity to absorb or adjust to rising prices for low income groups via the national tax and benefit system. This may be more difficult to achieve in developing countries due to political problems.

More emphasis should be placed on energy efficiency combined with the use of energy efficient technologies and demand-side management in advanced economies like the EU as final consumer electricity bills rise. The role of the regulatory body to generate the required level of investment and mitigate the adverse impact of electricity price rises would be equally important.

6.3. Further Research and Concluding Remarks

This thesis analysed the process and outcomes of market driven electricity reforms in developing, transition and developed economies. The findings cast doubt on the net benefit of competition arising from implementing market driven reforms in small electricity systems. Hence, evidence is needed to assert the appropriateness of full adoption of market driven reforms in small systems. Further research is required to estimate all the relevant costs and benefits of electricity reform in small systems using cost-benefit analysis. The use of SCBA in analysing the effectiveness of electricity reforms in developing countries is also limited in the literature implying a considerable knowledge gap. Hence, undertaking a SCBA of reforms can offer useful policy guidance for developing countries before implementing a comprehensive electricity reform.

The thesis also portrays mixed evidence of market-based reforms in improving electricity access in developing and transition countries. Market driven reforms have significantly improved electricity access in most of the LACs while the model has been less successful in South Asia in improving electricity access. In contrary, centrally planned models have been successful in delivering higher levels of electrification in transition countries. Universal electrification has also been successfully achieved in China despite a population over 1.3 billion. Hence, further research is required to assess the suitable model for improving electricity access in developing countries. Similarly, the thesis places greater emphasis on the importance of electricity wholesale market liquidity on electricity market integration across Europe. Further research can be carried out to examine the direct impact of market liquidity on wholesale price convergence among EU electricity markets.

It is evident from the thesis that electricity reform process remains a work in progress and an evolving process across all countries. A majority of the less-developed and developing countries are still on some stages of the standard reform menu. Some developed countries have established a well-functioning wholesale spot market for electricity but are suffering from chronic market power concerns coupled with the inability to sustain competition and lack of investment in the networks. Climate change and security of supply issues in the face of regulatory uncertainty have raised new problems and concerns in advanced economies such as the EU where reforms have already reached the advanced stages of the market-based reform process. For example, recent electricity reforms in the UK are being driven by capacity shortage concerns as is also present among the less-developed and developing countries. However, the contexts vary. While cost-reflective pricing and privatisation in the presence of sound regulation can mitigate the capacity concerns in developing countries; developed countries such as

UK will need a new market model and industry structure to increase the production and accommodation of renewable energy sources. This will discourage fossil-based generation in the transition towards a low-carbon economy and meet the EU energy policy goals and environmental targets.

The thesis reveals that electricity sector reforms remain a major economic, political and social challenge across all reforming countries in the world. This is because electricity reforms require coordinated progress on all aspects of the development process, namely political, macro-economic, sectoral, and financial to be successful. The interplay and intricacies between the economic, social and political factors complicates the reform process. Thereby, any qualitative and quantitative evaluation of the success or failure of the reform process is difficult irrespective of the evaluation of reforms being a matter of empirical testing or theoretical debate. It may be argued that the long-term consequences of market-based reforms in the electricity sector will be much clearer by qualitatively and quantitatively studying a longer reform discourse in the future. However, this is not a guarantee, as how long exactly 'long-term' is remains wholly unanswered. Further, new economic, political and technological challenges will continue to evolve the electricity sector as market based reforms continue to progress across all countries, though at varying speed. As such, it is clear that electricity sector reforms are an evolving and changing process rather than a one-off event. These factors lead to a unanimous conclusion that electricity sector reform is and will indeed remain a complex process across each economy.

The reliance on market based models and the extent to which electricity reforms have been pursued in each economy has reflected a general political belief in the efficacy of markets. However, competitive markets with independent regulatory bodies have exhibited significant market and regulatory failures as observed among the EU electricity markets. In contrary, the active involvement of the state in the electricity sector across developing countries has often demonstrated severe political failures in electricity sector management and operation as evident among some transition and most South Asian countries. The electricity market model in EU has also demonstrated considerable stress in delivering the large scale investment required for electricity infrastructure expansion to meet climate change targets and security of supply standards. This indicates the need to carefully assess whether future electricity sector reform process should involve a greater role of state intervention rather than a complete reliance on market and market-based solutions.

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